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Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

This Issue

EUROPEAN CARS

Part II—Engines (cont'd) and Chassis Components

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LUBRICATION

A TECHNICAL PUBLICATION DEVOTED TO THE SELECTION AND USE OF LUBRICANTS

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EUROPEAN CARS

PART II – Engines (continued)

THE November 1958 issue of this publication briefly discussed some of the major design features of European Cars. While some discussion of the lubrication requirements of their engines was included, space did not permit a complete review of this subject.

ENGINE LUBRICATION

It has been the practice of several European manufacturers to recommend a few specific lubricants as being satisfactory in a particular engine. This practice is not universal and is not followed by some of the major companies such as Mercedes-Benz, Volkswagen, Porsche and Fiat. These, among others, do not recommend specific lubricant *brands* but do indicate acceptable *types* such as "Heavy Duty" or "10W-30 Heavy Duty." A possible reason why this is not a universal practice in Europe is that European manufacturers are not yet acquainted with the standards of quality which are now available.

There are at least three major considerations in selecting a suitable crankcase oil. The first is its viscosity, the second is its oxidation stability and the third is its detergency qualities.

The SAE Crankcase Oil Viscosity Classifications system shown in Table I is now universally accepted both in the United States and in the European area as a means of designating viscosity. It has eliminated such ambiguous terms as "light", "medium", and "heavy" previously used in an attempt to designate the viscosity of an oil. It should be remembered that while viscosity is an important property, it does not define any other property such as detergency.

A discussion of oil "quality" should be preceded by a brief resumé of the changes in engine operating conditions and the great improvements which have been made in engine oils within the past two decades. With the advent of improved metallurgy and designs, higher speeds and greater engine outputs were developed. This in turn placed a greater emphasis on oil quality since the oil was required to run hotter and to support greater loads at the points of high stress. Higher oil temperatures required oils with greater oxidation stability to avoid excessive thickening. This was accomplished through the use of oxidation inhibitors. Higher loads at the points of high stress in the valve system required that additives be used to control the wear at these points.

In addition to this, the car itself was being used more for personal transportation. This naturally included a greater precentage of stop-and-go driving wherein engine temperatures remained low. With low engine temperatures, oil oxidation is negligible but unburned products of combustion such as fuel soot and the heavy portions of the fuel enter the crankcase and promote low temperature sludge, corrosion, and fuel varnish. Oil additives of the dispersant-detergent type were also used to overcome these operational problems.

Originally "Heavy Duty" oils were not necessary

TABLE I

SAE Motor Oil Grade Classification System

SAE Viscosity Grade Number	Viscosity, Saybolt Universal Seconds at 0°F. Minimum	Maximum	at 210°F. Minimum	Maximum
5W		4,000	39	
10W	6,000	12,000		
	or	12,000	40	
20W	12,000	48,000		
	or	48,000	45	
20			45	58
30			58	70
40			70	85
50			85	110

in automotive engines; however, as the conditions of operation became more severe, high temperature oxidation became the major problem. The first "Heavy Duty" oils were primarily high temperature lubricants which contained oxidation inhibitors and detergent-dispersant additives to minimize deposits from other causes. However, as the automobile became more popular, the major operational problem changed from high temperature oxidation to the deposits and engine corrosion associated with low temperature operation. This has naturally led to considerable confusion as to what now constitutes a "Heavy Duty" motor oil. In the API Engine Service Classification discussed below, "HD" oils are those recommended for at least Service MS.

Recognizing that confusion existed in the classification of oil quality and in the relating of this classification to service requirements, the American Petroleum Institute established a system of service definitions. This system is known as the API Engine Service Classification System and covers the various service conditions which are encountered by both gasoline and diesel engines. However, this system is not generally known or used in Europe and perhaps accounts for the continued practice by some European manufacturers of specifying only certain named brands of lubricants for use in their cars. The API system is followed in the United States since it gives the motorist a quality yardstick by which oil performance can be assured. In addition, since lubricant brands are not required nor even mentioned by domestic manufacturers, the motorist feels free to purchase any reputable oil that has the API Service classification appropriate to the engine operating conditions he imposes. The API system is discussed below and covers both gasoline and diesel engines.

By reason of their heavier fuel and operating cycle, diesel engines tend to promote more rapid oil contamination and oxidation which in turn requires a more highly detergent oil. Diesel engine lubricants are usually very satisfactory in gasoline engines since they give even greater protection against oxidation, corrosion and wear than is available in lubricants designed solely for gasoline engines.

The six API Engine Service Classifications in the order of increasing severity are as follows:

Service ML

This classification defines the least severe service classification for gasoline engines. It includes conditions where moderate speed driving or moderate load operation is encountered and where no severe low or high temperature condition exists.

Service MM

This classification defines the moderate to severe service conditions for gasoline engines. It includes engines operating under relatively high speeds or heavy loads. It does *not* include extensive operation under low engine temperatures caused by start-and-stop operation or prolonged idling.

Service MS

This classification represents the most severe service encountered in the operation of a gasoline engine. It includes both start-and-stop conditions as well as high speed and high temperature operation. Start-and-stop operation, while widely regarded as a relatively mild type of service, is in reality the most severe service condition to which an internal combustion engine can be subjected. In this type of service the engine and oil temperatures are low, which not only increases the *quantity* of partly burned combustion products but allows them to reach the crankcase where they promote low temperature deposits, clogged filters and oil screens, corrosion, and piston deposits. This condition is aggravated in wintertime and by prolonged idling. High temperature operation is also included in the MS service classification since high powers, high loads, and high speeds promote oil oxidation and may cause high temperature sludge and varnish deposits. Prolonged operation in hot weather tends to aggravate this condition. During either high or low temperature operation, wear may occur at points of high stress.

Table II, entitled Car Manufacturer's Motor Oil Recommendations, lists the available information for 1957 and 1958 cars. In those instances where Table II indicates the now obsolete "HD" oil, an oil recommended for at least API Service MS should be used.

Service DG

This service classification describes conditions of operation wherein the diesel engine is not subject to

any severe requirements and where wear and deposit control are not problems.

Service DM

This designation describes service typical of diesel engines operating under moderately severe conditions which would tend to promote deposits and wear. This service designation is more severe than that described in DG and requires an oil with a greater ability to control wear and reduce deposits. Oils meeting the DG and DM classifications give outstanding results in gasoline engines.

Service DS

This classification describes service typical of diesel engines operating under very severe conditions or having design characteristics or using fuels which tend to produce excessive wear or deposits. High load operation at high temperatures, design factors, especially supercharging or engine installation details which cause unusually high temperatures within the engine, constitute severe service, as does intermittent operation at low temperatures, since both promote wear and deposit formation. Oils meeting Service DS are not usually available at service stations.

Most all reputable oil suppliers within the United States specify the API Service condition for which their motor oils are recommended. For example, an oil suitable for moderate service conditions in a gasoline engine would be labelled "For Service MM". An oil suitable for several service conditions might be labelled "For Service ML, MM, MS, and DG".

No American automobile manufacturer specifies particular brand names of engine oils for use, but instead recommends lubricants meeting certain of the API Service Classifications. While this system has not been adopted yet by European manufacturers, more and more of them are abandoning the position of recommending a specific brand of lubricant and are now recommending oil types such as "Heavy Duty" or 10W-30 Heavy Duty.

OIL DRAIN INTERVALS

The subject of oil drain intervals is extremely complicated. This arises from the fact that each manufacturer uses a different engine design. Thus a given engine of manufacturer "A" may require oil changes at 1000 miles where the engine of manufacturer "B" may be able to run 1500 miles under the same conditions before a change is necessitated. For this reason, no attempt will be made to discuss the drain intervals of specific vehicles but the following discussion of the API Motor Oil Drain Intervals will indicate the factors involved.

City and Suburban Driving

City and suburban driving represents the ordinary use of the family car or light truck mainly on short run, start-and-stop service on paved roads under moderate air temperatures. It also includes some long distance travel at normal speeds. In such services, crankcases of average capacity should be drained approximately every 1000 miles. It has been determined that at least two-thirds of passenger car driving is under these conditions.

Cold Weather or Start-and-Stop Driving

Vehicle operation in freezing or subfreezing weather, especially in start-and-stop driving with much engine idling, is the most severe or adverse service. The hours that the engine operates or idles rather than the miles that the car is driven is the important factor affecting oil contamination and condition. Crankcase should be drained after not over 60 days or 500 miles of travel whichever occurs first. In extreme cases, more frequent draining may be necessary. Consistent driving over dusty roads is another adverse condition which necessitates an oil drain at 500 miles or more often, depending upon the severity of the dust conditions. For example, if a vehicle is driven through a dust storm, oil should be drained as soon as possible. Air cleaners should be serviced when the oil is changed.

Open Highway Driving

The most favorable driving condition is essentially open highway, intercity travel on paved, dust-free roads with little or no engine idling. In such service, the engine operates at efficient temperatures with efficient fuel combustion. Using high quality oils, there is little oil oxidation or accumulation of fuel residues to make deposits. Design details, such as large crankcase capacities, are also favorable factors. Under such conditions crankcase oil may be drained at a somewhat longer mileage than that recommended for city and suburban driving, but not to exceed 2000 miles.

In Table II is a list of 1957 and 1958 European Cars, together with their crankcase refill capacities stated in U.S. quarts. While the viscosity grade recommended by the manufacturer for operation under various ambient temperature conditions is shown, recommended oil drain periods are omitted, since some manufacturers do not specify a drain interval while others indicate periods ranging from 1000 to 3000 miles under favorable service conditions. All recommend more frequent draining as the operating service becomes more severe.

CLUTCHES

Manual Clutches

While the internal combustion engine has reached a high degree of efficiency and sophistication, it is not sufficiently flexible to permit the direct drive of the vehicle under all speed conditions. For this rea-

TABLE II — Car Manufacturer's Motor Oil Recommendations

Make	Model	Refill Capacity U.S. Qts.	Oil Type	SAE Viscosity Grade When Expected Ambient Temperature Is: Over 90°F.	32°F. to 90°F.	10°F. to 32°F.	—10°F. to +10°F.	Remarks
AC	2 Liter, Ace, Aceca	8.4[a]	Opt.	40	40	30	10W	[a]Add 0.9 qts. for filter
	Ace-Bristol, Aceca-Bristol	7.2[a]	Opt.	40	30	20	10W	
Alfa Romeo 1300	Giulietta, Sprint, Berlina, Sprint Spyder	6.2[a]	HD	40[c]	40[c]	30[c]	20[c]	[a]Add 1.0 qt. for filter
1300	Giulietta-Sprint Veloce	6.2[a]	HD	40[d]	40[d]	30[d]	30[d]	[b]Add 0.5 qt. for filter
1900		6.3[b]	HD	40	30	30	20	[c]Manufacturer recommends HD and Multi-Grade Oils (20W-40)
1900	C, TI, Super Sprint	6.3[b]	HD	40[c]	40[c]	30[c]	20[c]	[d]Manufacturer's Instructions: Below 50°F. (10°C) SAE 30 (HD oil), above 50°F. (10°C.) SAE 40 (HD oil). Multi-Grade oils not recommended for this model.
Allard	Monte Carlo Safari (Jaguar Engine)	12.0[a]	Opt.	40	30	20	10W	
	Monte Carlo Safari (Cadillac Engine)	5.1	HD	20	20	20	10W	
	Palm Beach MkII (Jaguar Engine)	11.4[a]	Opt.	40	30	20	10W	[a]Add 1.8 qts. for filter
	Palm Beach MkII (Zodiac Engine)	4.8[b]	HD	20	20	10W	10W	[b]Add 0.9 qts. for filter
Alvis	3 Liter	7.2	Opt.	30	20	20	10W	
Armstrong Siddeley	Sapphire 346, 346 (Special)	6.0[a]	Opt.	40	30	20	10W	[a]Add 0.6 qts. for filter
	Sapphire 234	6.0	Opt.	40	30	20	10W	
	Sapphire 236	6.3	Opt.	40	30	20	10W	
Aston-Martin	DB 2-4 MkII, Mk III, DB-3S	9.6	Opt.	40	30	20	10W	
Austin	A-30	3.6	Opt.	40	30	20	10W	[a]Add 0.8 qts. for filter
	A-35, A-40, A-50, A-55	4.2[a]	Opt.	40	30	20	10W	
	A-95, A-105	7.2[a]	Opt.	40	30	20	10W	
	Princess	10.3	Opt.	40	30	20	10W	
Austin-Healey	BN4 (100-Six)	7.2[a]	Opt.	40	30	20	10W	[a]Add 0.8 qts. for filter
	Sprite	3.6	Opt.	40	30	20	10W	
Bentley	S Series, Continental	9.6	HD	30	20	20	10W	
BMW	501 (6 Cyl.)	4.2[d]	HD	30[a]	20[a]	20[a]	10W[a]	[a]Manufacturer recommends 10W-30 and 20W-40 grades
	501 (V-8)	5.2[d]	HD	30[a]	20[a]	20[a]	10W[a]	[b]10W-30 grade may be used
	502S, 503, 507	6.4[d]	HD	30[b]	20[b]	20[b]	10W[b]	[c]Manufacturer recommends 10W-30 all year round.
	Isetta 300	1.8	HD	40	40	20	10W	[d]Add 0.5 qts. for filter.
	Isetta 600	2.1	HD	30[c]	30[c]	20[c]	10W[c]	
Bond	Minicar Mark E (2 Stroke)	[a]	St. Min	40	40	40	40	[a]6% Added to fuel.
Borgward	Isabella 60, TS	4.8	HD	30[a]	30[a]	20[a]	10W[a]	[a]10W-30 may be used in all seasons.
Bristol	405	7.2[a]	Opt.	40	30	20	10W	[a]Add 0.9 qts. for filter
	Arnolt-Bristol Bolide	—— No Information Available ——						
Citroen	DS-19, ID-19	4.2	Non Det.	20	20	20	10W	
	2-CV (Type AZ)	2.1	Non Det.	20	20	20	10W	

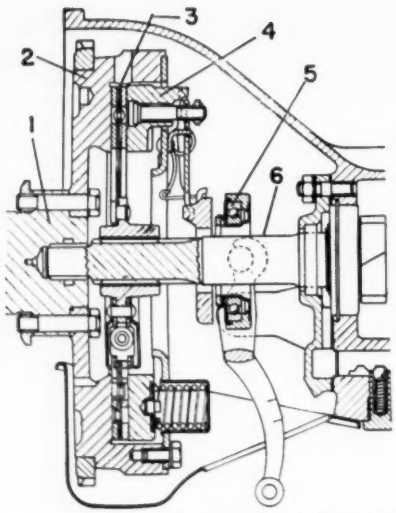
DAF	600	2.1	—— No Information Available ——					
Daimler	Conquest, Century	6.0	Opt.	40[a]	30[a]	20[a]	10W[a]	[a]From 1956, 10W-30 grade recommended for engine, gearbox and fluid flywheel.
	Regency (One-O-Four), MkII, Majestic	7.5	Opt.	40[a]	30[a]	20[a]	10W[a]	
	DK-400A	8.2	Opt.	40[a]	30[a]	20[a]	10W[a]	
DKW (Auto Union)	3 = 6 (2 Stroke), 1000	[a]	St. Min	30	30	30	30	[a]Oil-Gasoline mixture 1:40
Facel Vega	V-8	5.3[a]	HD	30[b]	30[b]	20[b]	20[b]	[a]Add 1 qt. for filter [b]10W-30 grade may be used in all seasons.
Ferrari	250 Gran Turismo	7.4	Opt.	30[a]	30[a]	20[a]	10W[a]	[a]Manufacturer recommends 10W-30 grade.
Fiat	La Nuova 500	1.8	Opt.	40[a]	30[b]	20[b]	10W[b]	[a]Manufacturer recommends 20W-40 since 1957. [b]Manufacturer recommends 10W-30 since 1957.
	600, 600 Multipla	3.2	Opt.	50[a]	30[b]	20[b]	10W[b]	
	1100, 1100 TV, 1200	3.2	Opt.	50[a]	30[b]	20[b]	10W[b]	
	1400A, 1400B	5.7	Opt.	50[a]	30[b]	20[b]	10W[b]	
	1900B	5.8	Opt.	50[a]	30[b]	20[b]	10W[b]	
Ford	Popular	2.4[a]	HD	40	30	20	10W	[a]Add 0.6 qts. for filter [b]Add 0.9 qts. for filter
	Anglia, Prefect	2.1[a]	HD	30	20	20	10W	
	Consul, Consul MkII	3.6[b]	HD	20	20	10W	10W	
	Zephyr, Zodiac	4.2[b]	HD	20	20	10W	10W	
Ford-Taunus	12M	2.6	Opt.	30	20	20	10W	[a]Add 0.3 qts. for filter
	15M	2.6	Opt.	30	20	20	10W	
	17M	3.2[a]	Opt.	20	20	20	10W	
Frazer-Nash	Sebring, Turismo	6.0	Opt.	30	20	20	10W	
Goggomobil	T-250, T-300, T-400 (2 Stroke)	[a]	St. Min.	40	40	40	40	[a]Oil-gasoline mixture 1:25
	TS-400 (2 Stroke)	[a]	St. Min.	40	40	40	40	
Goliath	GP-900E (2 Stroke)	3.1[a]	St. Min.	30	30	20	20	[a]Fuel Injection, oil added to fuel from separate tank. [b]Including oil cooler.
	1100	3.2	HD	30	30	20	20	
	1100 Delux	3.9[b]	HD	30	30	20	20	
Heinkel	154 (3 Wheel), 408B-1 (4 Wheel)	1.6[a]	Opt.	40	40	30	20	[a]Total capacity of crankcase and gearbox .
Hillman	Minx, Minx Series III	4.8	HD	30	20	20	10W	
	Husky Series 1	4.2	HD	40	30	20	10W	
Humber	Hawk	5.7[a]	HD	40	30	20	10W	[b]Add 0.6 qts. for filter
	Super Snipe Mk IV	8.4[a]	HD	40	30	20	10W	
Jaguar	2.4 Liter	7.8	Opt.	40	30	20	10W	[a]Add 1.2 qts. for filter [b]Add 1.8 qts. for filter
	3.4 Liter	6.6[a]	Opt.	40	30	20	10W	
	XK-150, Mark VII, VIII, IX	11.4[b]	Opt.	40	30	20	10W	
Jensen	541 Special, Interceptor, 541 R Series	9.0[a]	Opt.	30	30	20	10W	[a]Add 1.2 qts. for filter
Kieft	MT 1	—— No Information Available ——						
Lagonda	3 Liter	7.2	Opt.	40	30	20	10W	
Lancia	Aurelia 2500 GT	5.4	Opt.	40[a]	30[a]	20[a]	20[a]	[a]Manufacturer's Instruction: Below 32°F., SAE 20, From 32°F. to 68°F., SAE 30, Above 68°F. SAE 40 [a]Add 0.6 qts. for filter
	Appia Series 2	2.9	HD	40[a]	30[a]	20[a]	20[a]	
	Flaminia	6.3[b]	Opt.	40[a]	30[a]	20[a]	10W[a]	

TABLE II (Cont'd) Car Manufacturer's Motor Oil Recommendations

Make	Model	Refill Capacity U.S. Qts.	Oil Type	SAE Viscosity Grade When Expected Ambient Temperature Is: Over 90°F.	32°F. to 90°F.	10°F. to 32°F.	—10°F. to +10°F.	Remarks
Lloyd	LP-600	1.5	HD	40[a]	20[a]	10W[a]	10W[a]	[a]Manufacturer's Instructions: Below 32°F., SAE 10W or 10W-30; Between 32°F. and 84°F., SAE 20 or 10W-30; Over 84°F., SAE 40
Lotus	—— No Information Available ——							
Maico	500	1.2	St. Min.	40	40	40	40	
Maserati	A6G 2000	8.5	Opt.	30	30	20	NA	
	Sport 2000	23.8	Opt.	50	50	50	NA	
Mercedes-Benz	180A, 190, 190SL	4.2[a]	HD	30[d]	20[b, d]	10W[d]	10W[d]	[a]Add 0.5 qts. for filter
	219, 220S, 220SE	6.3[a]	HD	30[d]	20[b, d]	10W[d]	10W[d]	[b]Above 77°F. use SAE 30. Below 41°F. use SAE 10W
	300D	6.9[a]	HD	30[d]	20[b, d]	10W[d]	10W[d]	[c]Racing model 15.8 qts.
	300SL	11.6[c]	HD	30[d]	20[b, d]	10W[d]	10W[d]	[d]After 31,000 miles, use next higher SAE grade. Note: 10W-30 may be used for all seasons.
Messerschmitt	KR-200, KR-201	[a]	St. Min.	50	50	50	50	[a]Oil-Gasoline mixture 1:25
Metropolitan	B Series	4.2a	Opt.	30	30	10W[b]	10W	[a]Add 1.2 Qts. for filter [b]Above 20°F. use SAE 20
MG	MGA	3.9[a]	Opt.	30	30	20	10W[b]	[a]Add 0.6 qts. for filter
	MGA Twin Cam	6.7	Opt.	30	30	20	10W	[b]Above 0°F. use SAE 20
	Magnette (Series 11)	4.2[a]	Opt.	30	30	20	10W[b]	
Morgan	4/4 Series II	3.1	Opt.	30	20	20	10W	
	Plus 4	10.0[a]	Opt.	40	30	20	10W	[a]Add 0.6 qts. for filter
Morris	Minor 1000	3.6	Opt.	30	30	20	10W[c]	[a]Add 0.6 qts. for filter
	Oxford (Series III), Cowley	4.2[a]	Opt.	30	30	20	10W[c]	[b]Add 0.3 qts. for filter
	Isis (Series II)	6.6[b]	Opt.	30	30	20	10W[c]	[c]Above 0°F. use SAE 20
N.S.U.	Prinz	2.1	HD	20	20	10W[a]	10W	[a]Below 14°F.
Opel	Olympia, Rekord	3.2	Non Det.	20	20	20	10W[a]	[a]Above 0°F. use SAE 20.
	Kapitan	4.2	Non Det.	20	20	20	10W[a]	
OSCA	1100 2-AD	6.3	Opt.	40	40	30	20	
Panhard	Dyna	2.3	Opt.	40	30	20	10W	Note: 10W-30 may be used.
Peugeot	203, 403	4.2	Opt.	40	30[a]	20[a]	10W[a]	[a]10W-30 may be used.
Porsche	356A/1300, 1300S	3.2[a]	HD	30	30	20	10W	[a]5.3 qts. with filter
	356A/1600, 1600S	3.2[a]	HD	30	30	20	10W	[b]10.6 qts. with oil cooler and piping.
	356A/1500 GS	8.5[b]	HD	30	30	20	10W	[c]Special racing type oil
	550A/1500 RS (Spyder)	—	[c]	[c]	[c]	[c]	[c]	

Renault	750 4 CV	2.1	Opt.	20	20	20	10W	Note: 10W-30 may be used in temperate climates except in Transfluide.
	Dauphine	2.5	Opt.	20	20	20[c]	10W	[a]Crankcase 4.2 qts., Transfluide 3.2 qts.
	Fregate 2 Liter, Standard	4.2	Opt.	40	30	20[c]	10W	[b]Multi graded oils not approved.
	Fregate Transfluide	7.4[a]	Opt.	40[b]	30[b]	20[c]	10W[b]	[c]Above 15°F. use SAE 20
Riley	1.5 Liter	4.2[a]	Opt.	30	30	20	10W	[a]Add 0.6 qts. for filter
	2.6 Liter	6.3[a]	Opt.	30	30	20	10W	
	Pathfinder	7.5	Opt.	30	30	20	10W	
Rolls-Royce	Silver Cloud, Silver Wraith	9.6	Opt.	30	20	20	10W	
Rover	60	6.0[a]	HD	40	30	20	10W	[a]Add 1.2 qts. for filter
	75, 90E, 105S	8.4[b]	HD	40	30	20	10W	[b]Add 0.6 qts. for filter on model 75 after 1949.
	105R	14.4	HD	40	30	20	10W	
SAAB	93B, GT-750	a	St. Min.	40	40	40	40	[a]3% Oil in fuel.
Simca	Aronde, Montlhery, Ariane 4	5.3	HD	40	30	20	20	
	Ariane V-8, Vedette	4.7	HD	40	30	20	10W	
Singer	Gazelle	4.5[a]	Opt.	40	30	20	10W	[a]Add 0.3 qts. for filter
Skoda	440, 445, 450	3.2	Opt.	40	40	20	20	
	1201	2.6	Opt.	40	40	20	20	
Standard	Eight, Ten, Pennant	3.9[a]	Opt.	40	30	20	10W	[a]Add 0.3 qts. for filter
	Ensign, Vanguard III	6.0[a]	Opt.	40	30	20	10W	
Sunbeam	Mark III	6.3	HD	40	30	20	10W	
	Rapier	4.8	HD	30	20	20	10W	
Talbot	2500 Rapide	10.6	Opt.	40[a]	30[a]	20[a]	20[a]	[a]For running in period use SAE 20.
	Talbot-America	5.3	Opt.	40[a]	30[a]	20[a]	20[a]	
Tatra	603 V-8	— No Information Available —						
Triumph	TR-3	6.0[a]	Opt.	40	30	20	10W	[a]Add 0.6 qts. for filter
	Ten	3.9	Opt.	40	30	20	10W	[b]Add 0.3 qts. for filter
Vauxhall	Cresta, Velox	6.0	Opt.	30	20	20	10W	
	Victor	5.1	Opt.	30	20	20	10W	
Volkswagen		2.6	HD	30	20W	10W	10W	Note: 10W-30 may be used in all seasons.
Volvo	PV-444 L, Amazon	3.0[a]	Opt.	30	20	10W	10W	[a]3.9 qts. when filter is serviced.
Wolseley	Fifteen-Hundred	3.9[a]	Opt.	30	30	20	10W	[a]Add 0.3 qts. for filter
	Fifteen-Fifty	4.2[b]	Opt.	30	30	20	10W	[b]Add 0.6 qts. for filter
	Six Ninety	6.9	Opt.	30	30	20	10W	

Abbreviations: HD = Heavy duty (detergent) Use API Service Designation MS or higher. Non Det = Non-detergent
Opt. = Optional (either detergent or non-detergent) St. Min. = Straight mineral



Courtesy of S.A. Alfa Romeo, Milan, Italy

Figure 1 — Alfa Romeo Single Disc Clutch
1—Engine Crankshaft, 2—Engine Flywheel, 3—Clutch disc, 4—Pressure plate, 5—Clutch release bearing, 6—Transmission input shaft.

son some type of speed changing gear is necessary. In order to change speeds the engine must be disconnected from the drive line for a short instant to allow a different gear to be brought into play. Initially this was done through the use of belts and pulleys. Modern design uses a clutch which is located between the engine and transmission or in the case of an automatic transmission, within the transmission itself.

In its simplest form a clutch consists of a disc of friction material which is coupled to the transmission input shaft and can be held against the engine flywheel face by a "pressure plate". When the clutch pedal is depressed, the "pressure plate" is drawn away from the flywheel releasing the clutch disc which is then free to rotate independently of the engine. This then permits the gears to be shifted with a minimum of effort.

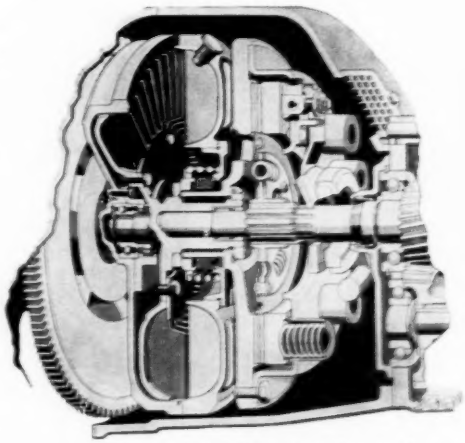
All cars use a clutch of some type. The most common is a simple plate clutch rotating within a housing where air can be used as a coolant. A typical example of this design is found in the Alfa Romeo Giulietta clutch shown in Figure 1. Racing cars such as the Jaguar D type, Ferrari and Maserati, often use clutches containing more than one disc in order to transmit the higher engine torques developed. Air cooling is used in these designs. Multiple disc clutches are also used in some of the economy cars such as the Goggomobil and Berkeley. However, in these instances they are "wet" clutches since oil is used as a coolant.

The operation of manual clutches is done by connecting a foot pedal to the clutch release bearing. Traditionally this has been accomplished by the use of suitable mechanical linkages so as to obtain the desired motion at the clutch. Since 1953, hydraulic operation of the clutch has become increasingly popular. Jaguar, Triumph and others use this method wherein the foot pedal operates a hydraulic piston and is not directly connected to the clutch mechanism. The hydraulic pressure produced is then transmitted through a tube to a slave piston near the clutch. The slave piston moves when the clutch pedal is depressed and releases the clutch. The advantages of this system are that complicated linkages, vibration, and linkage wear are all eliminated.

Automatic Clutches

With the increasing use of the automobile in the European area, increased emphasis has been placed on the automatic or semi-automatic type of driving. To take the manual effort out of gear changing, several automatic clutch designs have recently become available. The Mercedes-Benz "Hydrak" and the Renault "Ferlec" clutch are representative of two different approaches to the problem. The Mercedes-Benz "Hydrak" utilizes a series of electric interlocks to apply engine manifold vacuum to a clutch operating piston. As the gear lever is grasped, preparatory to shifting, the clutch is automatically disengaged and then reapplied at the completion of the manual shifting cycle. A fluid coupling is also incorporated to insure a smooth engagement. No clutch pedal is used in this design which is shown in Figure 2.

The "Manumatic" automatic clutch, as available on the Hillman Minx, uses the same general system



Courtesy of Daimler-Benz A. G., Stuttgart, Germany

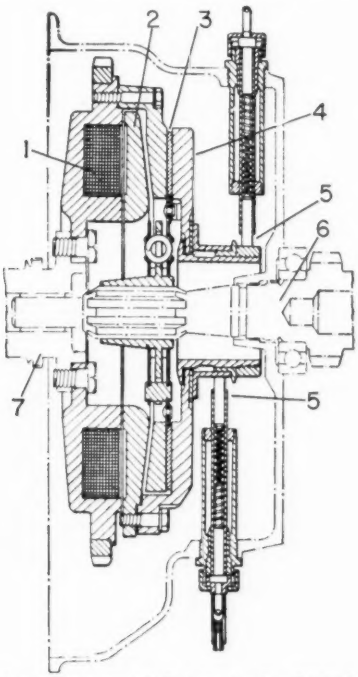
Figure 2 — Mercedes-Benz "Hydrak" automatic clutch showing engine flywheel, fluid coupling, and conventional disc clutch.

as the "Hydrak" except that the fluid flywheel is omitted through the use of a more sophisticated electrical interlock system. The "Saxomat" system, available on the Ford Taunus and DKW 3-6 and 1000, is similar in operation.

A similar shifting procedure is followed in the Renault Dauphine equipped with a "Ferlec" clutch. The major difference is that although it does use a conventional clutch disc, an electromagnet in the flywheel operates the pressure plate which engages the disc and thereby transmits engine torque. This design is shown in Figure 3.

The Renault "Transfluide" combines some of the components of both of these systems and uses a magnetically operated clutch similar to the "Ferlec", together with a three element torque converter to obtain automatic clutch operation. In this design engine oil is used in the torque converter.

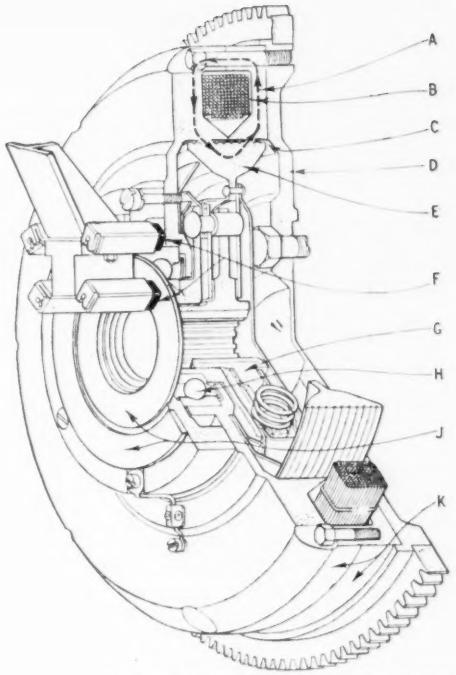
The Smiths "Selectroshift" magnetic particle clutch is another approach to the problem of obtaining an automatic clutch. It consists of two rotating members, one coupled to the engine and the other to the transmission. No direct connection is made between these two members but torque is transmitted through the small gap between them by means of magnetic particles. When the particles are magnetized by an external magnetic field, they tend to "solidify" and thus form a solid connection between engine and transmission. Any degree of slip can be obtained by adjustment of the magnetic field. This design is shown in Figure 4.



Courtesy of Automobile Engineer, London, England

Figure 3 — Renault "Ferlec" Electrically Operated Automatic Clutch

1—Magnetic coil, 2—Armature, 3—Clutch disc, 4—Pressure plate, 5—Contacts, 6—Transmission input shaft, 7—Engine output shaft.

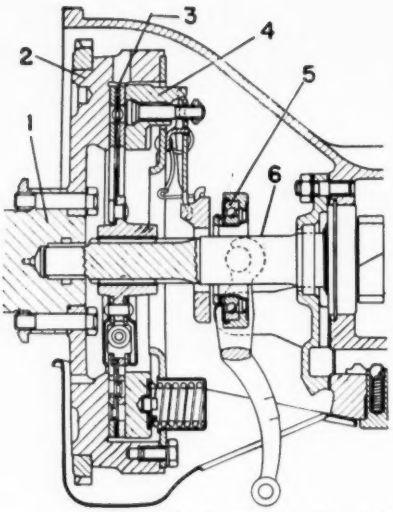


Courtesy of Automobile Engineer, London, England

Figure 4 — The Smiths "Selectroshift" Magnetic Particle Clutch A—Magnetic flux path, B—Magnetic coil, C—Gap, D—Engine flywheel, E—Armature, F—Contact brushes, G—Clutch hub, H—Clutch hub support bearing, J—Contact rings, K—Magnetic field pieces.

Another automatic clutch system is the "Newtondrive" which uses a combination of a centrifugal and power assisted clutch engagement to effect automatic operation. This system is used in the English Ford and in modified form in the Standard Ten.

It will be noted that those automatic clutch systems which permit some slip either through the use of a fluid coupling or a torque converter are generally not used on the smallest European cars where maximum fuel economy is a prime consideration. These cars use only manually operated clutches or an automatic system which does not permit slip when fully engaged. Examples of this type would be the "Ferlec" clutch in the Renault Dauphine and the "Newtondrive" which is available on the small English Fords and Standards.



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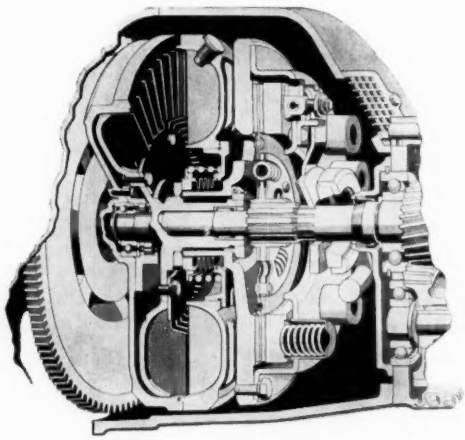

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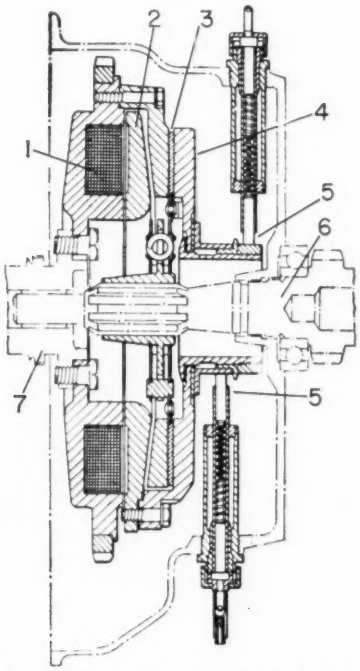

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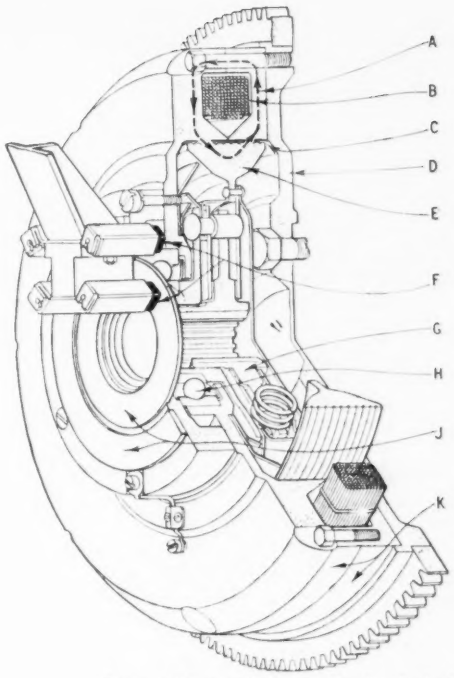

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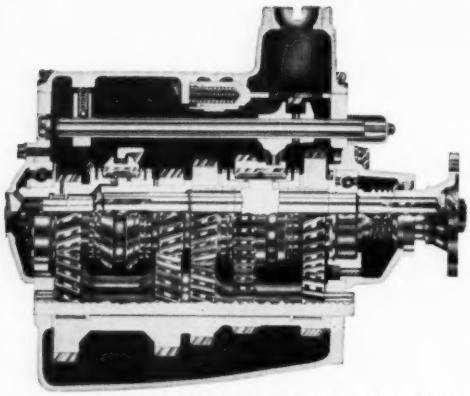


Courtesy of Aktiebolaget Volvo, Gothenburg, Sweden

Figure 5 — Volvo PV-444 Four Speed Transmission Showing Synchronizers Fitted to All Forward Speeds. Transmission Attaches to the Clutch at the Left.

Clutch Lubrication

Normally the manually operated clutch mechanism need not be lubricated. The clutch throw-out bearing is usually lubricated with a suitable grease and sealed for life. In those designs where a graphite on steel throw-out bearing is used, no lubrication is required. If mechanical linkages are employed, their connections are usually lubricated with the recommended chassis grease or, if no grease fittings are available, by the hand application of engine or gear oil. Hydraulically operated clutches usually use hydraulic brake fluid as the hydraulic medium. Care should be taken to use the recommended quality since poor quality fluids may vaporize due to the proximity of the engine exhaust system.

Automatic clutches generally need no greater care than their manually operated counterparts. Those systems wherein fluid flywheels or torque converters are used do, in some cases, require special lubricants. Those such as the "Transfluide" are fed with engine oil and therefore do not need special fluids. However, fluid clutches such as are used in the Mercedes-Benz "Hydrak", which are separately filled, require an Automatic Transmission Fluid (ATF). This fluid will be discussed further in the section on Transmissions.

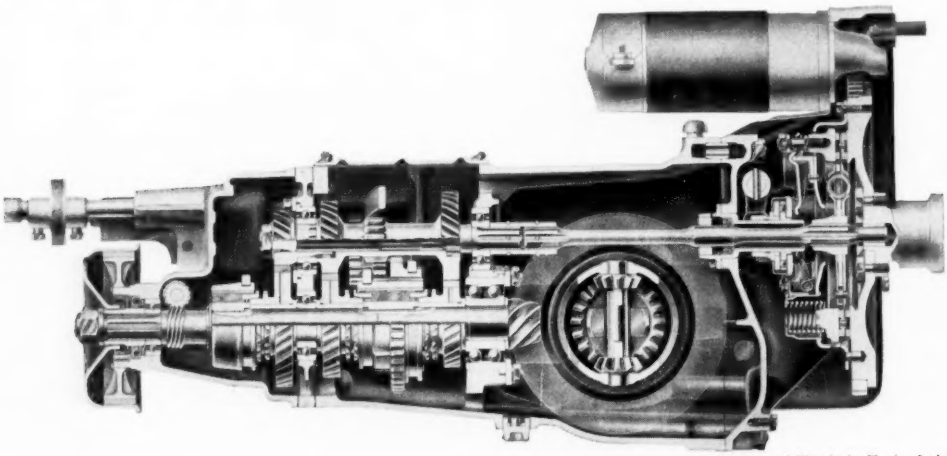
TRANSMISSIONS

European Car transmissions cover a wide range of designs. The large cars can and do utilize semi or fully automatic transmissions since fuel economy, service, and replacement costs are of little concern to the owner. Cars appealing to the middle bracket buyer usually have manual transmissions but may have certain semi-automatic features optionally available. Economy cars do not have these features and are strictly utilitarian.

Manual Transmissions

Since most European Cars are equipped with manual transmissions, an examination of some of their features is in order. As discussed earlier, the transmission is necessary so as to permit the car to be operated over a wide speed range by an engine whose usable speed range is limited. The difference between these two factors determines how many speeds a given transmission must have when installed in a given car.

A great majority of European Cars use a four speed transmission. Some manufacturers such as Vauxhall, British and German Ford, Renault,



Courtesy of Fiat S.A., Turin, Italy

Figure 6 — Fiat 600 Four Speed Transmission Showing Synchronizers Fitted to the Top Three Speeds and General Arrangement of Spiral Bevel Gear Differential, Single Disc Clutch and Starter.

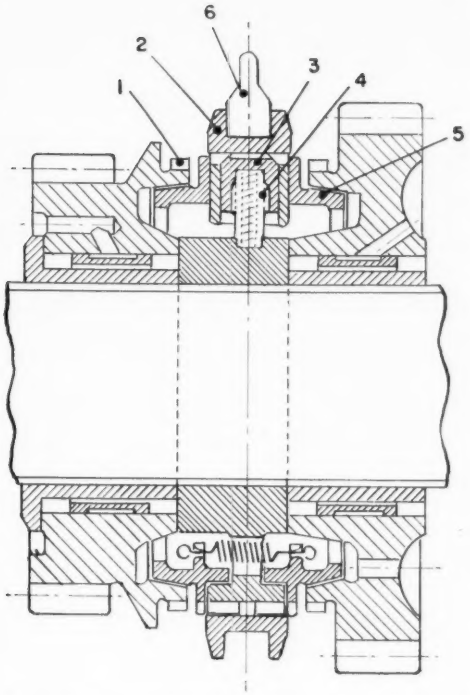


Figure 7 — Schematic View of "Constant Load" Type of Synchronizer
1—Dog clutch teeth on gear. 2—Dog clutch, driven by main shaft, and fitted with internal teeth which engage dog clutch teeth on gear, 3—Constant load piston, 4—Constant load spring, 5—Synchronizer cone clutch which is forced into engagement with cone clutch on gear to effect synchronization, 6—Shifting fork connected to gear shift lever.

Simca, and Standard use three speed transmissions. A few such as Ferrari and Maserati use five speed transmissions. Regardless of the number of speeds used, all of these designs fall into two general categories. In one type, the power is transmitted straight through from front to back. In the other type, the power is taken out the same end that it goes in. An example of the first type is found in the 1959 Volvo PV-444 transmission shown in Figure 5. The second type of transmission is found in those cars using a combination transmission and differential unit. Typical examples of this type are found in the Renault Dauphine, Volkswagen, SAAB, DKW, Fiat 600, Citroen DS-19. All of these cars use either front wheel drive or have the engine mounted in the rear in close proximity to the differential. A typical example of this general type of design is the Fiat 600 which is shown in Figure 6. This type of unit has some advantages in that no drive shaft is necessary to transmit the torque from the transmission to the differential unit. A more complete discussion of the combined transmission and differential will be given later.

An examination of both Figures 5 and 6 will indicate that in both of these transmissions some gears are in mesh or engaged at all times. For this reason, the modern transmission is known as a constant mesh type. The gear changes are not accomplished by the actual engagement of the gear selected but by coupling the desired gear to the output shaft since all synchronized gear ratios are rotating constantly. The coupling is actually done by means of a sleeve containing internal teeth which is connected to the output shaft. The sleeve is slid either forward or backward in order to engage mating external teeth attached to the desired gear. Were this sleeve to be engaged with the two sets of teeth moving at different speeds, clashing of the gears would occur. To eliminate this possibility, all modern manual transmissions are equipped with "synchronizers". These are devices which insure that the teeth do not engage unless they are rotating at the same peripheral speed. Most transmissions have at least the top two or three gear ratios synchronized, however, in some such as the Volvo, Mercedes-Benz and Vauxhall all forward speeds are synchronized.

There are two general types of gear synchronizers. One is the so-called "constant load" or "balk ring" type and the other is the "Porsche" or "self energizing" type. The "constant load" type consists of a brass or bronze cone clutch which, while rotating

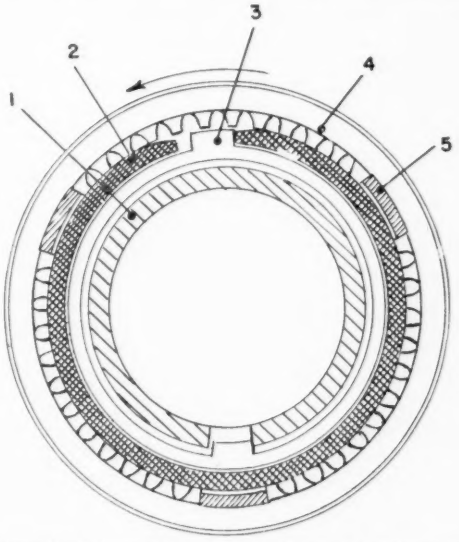
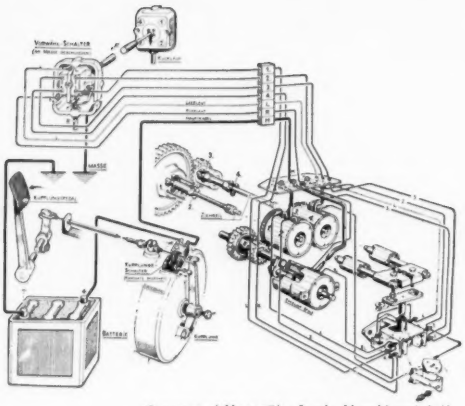


Figure 8 — Schematic View of "Porsche" Type of Synchronizer
1—Driving ring fitted to gear to be synchronized, 2—Split ring which expands while gears are being synchronized and forces cone clutch into engagement, 3—Split ring driving member, 4—Dog clutch with internal teeth, 5—Dog clutch driving arms fitted to transmission mainshaft.



Courtesy of Hans Glas Isaria-Maschinenfabrik, Dingolfing/Bayern, Germany

Figure 9 — Schematic Diagram of "Getrag" Electric Preselective Transmission Showing Shifting Lever, Wiring, Gear Shifting Electromagnets, Clutch and Actuating Switch on Clutch.

with one gear, is forced against the gear to be engaged and thus brings the speed up or down to the same speed as the gear being engaged. Since the force engaging this cone clutch is controlled by a spring whose pressure is constant, this synchronizer system is called the "constant load" type. A schematic view of a typical design of this type is shown in Figure 7.

The "Porsche" type of synchronizer, shown schematically in Figure 8, contains an expanding ring which is actuated by the relative speeds of rotation between the two sets of engaging teeth. This speed difference causes the ring to expand outward and synchronize the gears. In this system, the force applied to the synchronizing ring is directly proportional to the relative speeds between the two shafts and the force being applied to the shifting lever. Engagement of the selected gear cannot be completed until complete synchronization is achieved. This type of synchronizer permits more rapid shifting than is possible with the more conventional balk ring type. It is used by Porsche and others including the latest Goggomobil T-700 and Ferrari 250 as well as many racing cars such as the Formula 1 Ferrari Dino 246 V-6.

Semi-Automatic Transmissions

Although it has been customary to consider all transmissions whose functions are conducted either automatically or at the command of the driver as automatic transmissions, for the purpose of discussion those units which will only shift at a definite command from the driver will be considered to be "Semi-Automatic".

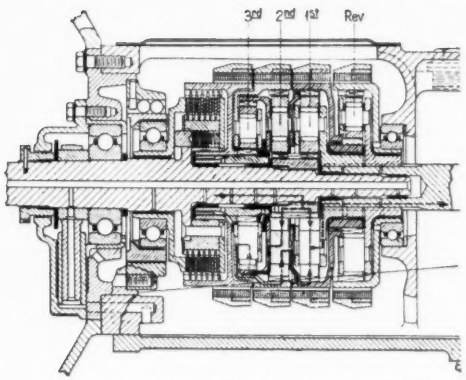
Although Semi-Automatic Transmissions are more expensive than manual transmissions, they are used on economy, middle and high priced automobiles. Many are merely adaptations of conventional manual transmissions in which direct gear changes are made automatically. While their initial cost is higher, their use on the economy cars is justified since they do allow the car to be directly driven through gears and thus permit no slippage. A typical example of this type of application is the Goggomobil TS-300 and TS-400 which use the "Getrag" electromagnetic shift. This system uses an electrical system to effect gear changes when the clutch is depressed. In effect this is a "preselective" type of unit since the desired gear can be selected at any time prior to when the actual shifting is accomplished. This is possible since the electrical circuit is not energized until the clutch is depressed. A schematic diagram of the Getrag system is shown in Figure 9.

Another type of semi-automatic preselector transmission is the Wilson Preselective transmission available on the Daimler DK 400. The gear train portion of this unit is shown in Figure 10. The unit as a whole consists of a fluid flywheel and a series of epicyclic gear sets which can be used individually or in combination to obtain the desired gear ratio. These ratios are brought into play hydraulically at the command of the driver through the use of a gear change pedal. While the desired ratio can be previously selected, it is not engaged until this pedal is depressed.

Aside from the preselective type of transmission, those units where the gear changes are accomplished by the direct movement of the shifting lever but where the clutch is operated automatically may also be regarded as in the semi-automatic transmission category. In this category are the Renault Dauphine which uses the "Ferlec" electric clutch, the Renault Transfluide drive, the Hydrak, Saxomat, and Manumatic systems, and the Smiths Selectroshift transmission. The Citroen DS-19 front wheel drive also uses a semi-automatic transmission which utilizes hydraulic pressure, developed by an engine mounted pump, to automatically declutch and change gears at the driver's command.

Fully Automatic Transmissions

Fully automatic transmissions are generally found only on those cars where first cost and economy of operation are not major considerations. There are available a number of interesting designs other than those commonly used in the United States. The Smiths "Autoselective" drive is an example of this type. In this unit the entire operation of declutching and gear changing is accomplished electrically. An electrically operated conventional transmission coupled with a modification of the Smiths electric clutch, discussed previously, provides fully automatic operation. The advantages of this system are that since no fluid flywheel or torque converter



Courtesy of Automobile Engineer, London, England

Figure 10 — Wilson Preselective Gearbox Showing Epicyclic Gear Sets. Fluid Flywheel and Engine attach at the left and power is transmitted to differential and rear wheels at right.

is used, high transmission efficiencies are obtained.

Another type of automatic transmission is typified by the "Roverdrive" which was available on the Rover 105R. This consisted of four elements; a torque converter, a conventional disc clutch operated by a vacuum servo, a two-speed transmission and an automatic overdrive unit. By means of electrical circuits, these elements were made to operate automatically. The overdrive was brought into play automatically based on vehicle speed. Either "drive" or "low" gear could be engaged by the movement of a conventional, column-mounted lever but once this is accomplished, all other drive functions were accomplished automatically in response to power demands and road speed. Recently Rover abandoned this system in favor of the Borg Warner transmission discussed below.

A great number of British cars have, as either standard or optional equipment, automatic transmissions based on two general United States designs. Both Rolls Royce and Bentley manufacture and use under license the Hydra-Matic transmission which is used in three General Motors cars. This transmission was discussed in detail in the February 1956 issue of Lubrication. This transmission is also used in the Austin Princess Saloon and is optionally available in the Allard Monte Carlo.

The Borg Warner automatic transmission is available as optional equipment on a wide variety of cars. Among these are the complete Jaguar line, the Standard Vanguard, the Austin A-95 and A-105, the Humber Hawk and Super Snipe, the Ford Zephyr and Zodiac, the Rover 3 Liter, and the Mercedes-Benz 219, 220S and 220SE. It is supplied as standard equipment on the Armstrong Siddeley Sapphire 346 and the Mercedes-Benz 300D. Its construction is similar to the unit used on the Studebaker in the United States and consists of a single plate clutch, a torque converter and an automatic epicyclic gear box. The plate clutch is used in direct drive to eliminate the slip which would occur were only a torque converter used. The torque converter is used in the low and intermediate gears to provide smooth power transmission, with additional torque multiplication. This transmission was discussed in detail in the June 1951 issue of Lubrication.

The "Variomatic Drive" is a new and very unique type of automatic drive that has recently appeared on the DAF manufactured in Holland by van Doorne's Automobiel-enAanhangwagenfabriek N.V. This system consists of an automatic centrifugally operated friction clutch unit which transmits the drive from the engine to a load divider located at the rear. Forward and reverse gears are located at this point. From this unit the drive is split and operates two variable diameter pulleys which in turn drive belts connected to similar pulleys at each rear wheel as shown in Figure 11. There is no transmission as such since the engine speed is automatically adjusted to the road requirements by the driving pulleys. The diameter of the driving pulleys can vary depending on road load and is assisted by engine manifold pressure. Should the engine tend to labor as when mounting a grade, the effective diameter of the two driving pulleys decreases. Similar pulleys at the rear wheels then increase their operating diameter through the action of springs thus keeping the belts tight. The change in the ratio permits the engine to speed up thus providing more power for gradients. The interesting part of this arrangement is that no differential unit is used and thus should one wheel slip due to poor traction, no loss of driving torque will occur on the other wheel. During cornering, the pulleys adjust so as to permit the outside wheel to turn faster.

Overdrive Units

Overdrive units are available for optional installation on many European Cars equipped with manual or semi-automatic transmissions. Their function is to permit high speed cruising with engine speeds reduced below that normally ob-

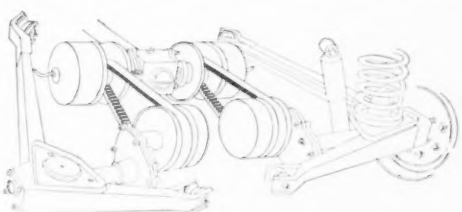


Figure 11 — Schematic View of DAF Final Drive System Showing Load Divider, Variable Diameter Driving Pulleys, "Vee" Belts and Rear Suspension Members.

tained in the top transmission gear. Operation under this condition reduces engine wear and improves fuel economy.

The Laycock deNormanville and Borg Warner units are the two major types available. Both units contain an epicyclic gear set which, when brought into play, reduces the transmission and engine speed with respect to the road speed. The Laycock deNormanville unit is entirely automatic in nature allowing shifting in or out of overdrive merely by the actuation of a switch located on the dashboard or gear shift lever. Movement of the switch applies hydraulic pressure to a small clutch in the overdrive unit so as to bring the epicyclic gear train into operation. This can be done with no interruption of the driving power. The overdrive function of this unit is usually restricted to the top gear but a special arrangement can be made to permit its use with intermediate gears if desired.

The Borg Warner unit is also automatic except that to engage overdrive, the foot must be lifted from the throttle for a short period while engagement occurs. To down shift to conventional drive the throttle is pressed to the floor which momentarily interrupts the engine ignition to permit the shift. This unit also has a governor which prevents the engagement of overdrive below a certain road speed. In addition, the unit can be locked in conventional drive by a lever manually controlled from the driving position.

Usually overdrive units are not fitted to the economy cars, however recently a simplified design has become available wherein the engagement of overdrive is accomplished manually by a dashboard control. This eliminates the necessity of complicated hydraulic and/or electric controls and results in a very economical unit.

Transmission Lubrication

As a result of the many different transmission designs, several different types of lubricants are used in transmissions. Many manual or semi-automatic transmissions use engine oils of the proper viscosity. Others use either straight mineral or compounded gear oils. Preselective types, such as the Wilson, can also use engine oil even though the lubricant must also act as an hydraulic medium to accomplish the desired gear changes. Fully automatic transmissions have somewhat different requirements in that the oil used must not only lubricate, but act as an hydraulic fluid to transmit power for the shifting cycles. In addition, it must also actuate the delicate internal controls which time the shifting cycles in accordance with throttle position, engine and road speeds.

Both the Laycock deNormanville and Borg Warner overdrive units are attached to the transmission and utilize the same oil supply. Thus the comments regarding the lubrication requirements of transmissions will also apply to these units.

TABLE III

Transmission and Axle-Lubricant Classification

(Viscosity Values in Saybolt Universal Seconds, (SUS)

SAE Viscosity Number	Viscosity at 0°F		Viscosity at 210°F	
	Minimum	Maximum	Minimum	Maximum
75	—	15,000	—	—
80	15,000[a]	100,000	—	—
90	—	—	75	120[b]
140	—	—	120	200
250	—	—	200	—

[a]The minimum viscosity at 0°F. may be waived if the viscosity is not less than 48 SUS at 210°F.

[b]The maximum viscosity at 210°F. may be waived if the viscosity is not greater than 750,000 SUS at 0°F. (extrapolated).

The actual lubrication system of the manual, semi-automatic, or preselective type of transmission varies widely. Most manual transmissions are lubricated by the immersion of the gears in the lubricant. Others, where the lubrication requirements are more severe, incorporate a pump to circulate the gear oil. This is usually the case in high performance vehicles such as the Mercedes-Benz 300 SL, Lancia and many racing machines. The Wilson preselective transmission also incorporates a pump to provide the necessary hydraulic pressure to accomplish the gear changes.

The lubrication requirements of these transmissions are controlled by several basic factors. The first is the temperature range over which the specific lubricant must operate. If the range is too wide, the oil may thin excessively at high temperatures and thus not provide sufficient wear protection for the gears and bearings. At very low temperatures, the oil may actually become so solid that it will not flow and thus cause the gears to run dry and wear excessively. For this reason, the viscosity grade of gear oils used in manual transmissions is varied according to the expected ambient temperatures. The viscosity of gear oils is generally higher than the normally used engine oils and conforms to the requirements of the SAE Gear Lubricant Viscosity Classification System shown in Table III. This method of specifying gear oil viscosity is used both in the United States and in Europe. It should be remembered, as in the case of engine oils, *that viscosity does not define oil quality.* This point will be covered more fully in the discussion of Final Drive Lubricants.

Engine oils are also widely used as transmission lubricants. Table IV lists the requirements of the European Cars on which information is available and indicates whether a gear oil or an engine oil is

suitable. Engine oils are listed by their SAE grades ranging from the SAE 10 through SAE 50. Gear Oils are listed by their grades which range from SAE 75 to SAE 250. The notes referred to along with the car name give the expected temperatures above and below which the recommended oil viscosity grades should be used.

The second consideration is the oxidation stability of the oil. Under the conditions of operation, high temperatures are developed. This tends to promote excessive oil oxidation and thickening of the oil. All top quality engine and gear oils contain sufficient oxidation inhibitors to prevent this.

The lubrication system of most automatic transmissions is rather complicated. This is necessarily so since these units contain many more parts than do manual transmissions. In addition, the lubricant must act as an hydraulic medium for both the control and shifting systems. To effectively perform the required function an Automatic Transmission Fluid (ATF) must possess unusual properties. It must have a high resistance to changes in viscosity with temperature or in other words, a high viscosity index. This is necessary since the shifting control is sensitive to wide viscosity changes and the transmission must operate over a wide temperature range. The oil must also have a low pour point so as to be able to operate at low temperatures. In addition, a certain amount of load carrying ability must be built in through the use of EP additives and finally, it must have good oxidation and foam resistance. In the United States, oils must demonstrate their ability to meet these severe requirements by passing very stringent laboratory and transmission tests in neutral laboratories. When they have successfully completed these tests, they are assigned an AQ number indicating this fact. Lubricants of this type have given satisfactory performance in both the Hydra-Matic and Borg Warner automatic transmissions in the United States. Transmission oil drain periods vary widely depending on the design and type of service encountered. No attempt has been made to tabulate these requirements and for specific information, reference should be made to the owner's manual.

DIFFERENTIAL AND FINAL DRIVE UNITS

Differential and final drive units are used to transmit the engine torque to the driving wheels. These units can be considered to be of two major types. One type utilizes a differential unit mounted as part of the back axle assembly. This conventional differential unit consists of a housing containing a pinion and ring gear together with an arrangement for dividing the driving torque and allowing one wheel to turn faster than the other as when negotiating corners. The type of pinion and ring gear arrangement used may vary depending on the personal preference of the manufacturer. Many designs use the so-called "hypoid" gearing principle shown schematically in Figure 12, which permits the centerline of the pinion shaft to be lower than the rear axle shaft. This arrangement allows a lower drive shaft "hump" on the car floor and adds to the room available within the car interior. This design is used in all cars produced within the United States.

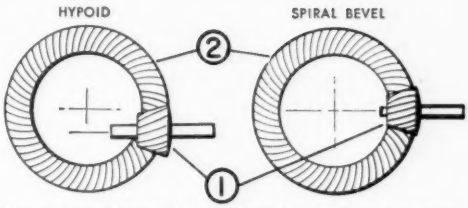


Figure 12 — Schematic View of Hypoid and Spiral Bevel Gearing Showing Location of Pinion and Ring Gear in Each Configuration.
1—Pinion Gears, 2—Ring Gears which are driven by the pinion gears.

A second design, which is somewhat easier to manufacture, uses the spiral bevel gear system. In this system, shown schematically in Figure 12, the centerline of the pinion gear is at the same level as the rear axle.

An extension of the "hypoid" design is the worm drive used in the Peugeot 403. In this system, the engine drives a worm located at the bottom of the differential gear case which in turn rotates a worm wheel connected through differential gears and axles to the rear wheels. This permits the lowest possible floor hump and provides the maximum leg room of all designs where the differential case is a part of the rear axle. Lower floor humps can be obtained with independent rear suspension systems wherein the differential is mounted on the frame and the wheels are driven through swing axles. A more complete discussion of these designs will be given later.

Contrary to the trend in the United States, limited slip differentials are not in general use in European Cars. High cost may be the major factor deterring their consideration although some manufacturers have limited slip drives. Among these are the Jaguar which has the Thornton "Powr-Lok" available as optional equipment, the Mercedes-Benz 300 SL and the DAF which was discussed earlier. The Thornton "Powr-Lok" is similar to those units available in the United States. In this design, should one wheel slip, small multiple disc clutches transmit engine torque to the wheel which has better traction. The Mercedes-Benz unit is manufactured by Z-F (Zahnradfabrik Friedrichshafen) and consists of a series of pawls driven by the ring gear. No differential gear is used as

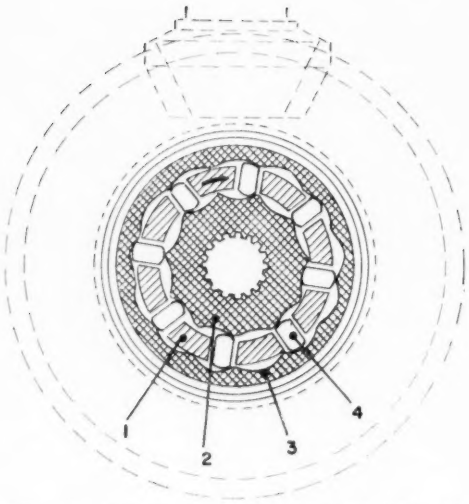


Figure 13 — Schematic View of Z-F Limited Slip Differential. 1—Driving member attached to ring gear, 2—Inner convolute cam attached to one rear wheel, 3—Outer convolute cam attached to other rear wheel, 4—Driving pawls.

the drive is transmitted by the pawls to an inner and outer convolute cam, one of which is attached to each wheel. This design is shown in Figure 13. When the car is driving straight ahead, there is no relative motion between the left and right wheel and thus the pawls do not slide over either of the cams. Should the wheel attached to the outer cam turn faster than the other as in turning a corner, the outer convolute would also turn faster than the inner. In this case, the pawls move as driving power is applied and slide in and out as they ride over the crests of the cams. However, even though they are sliding, they continue to provide equal power to both wheels. If one wheel slips due to loss of traction, the cam angles are so arranged that the torque available to drive the wheel with better traction is multiplied several fold so that the vehicle can be moved under adverse conditions. This general design has been in existence for some time having been widely used in German Army Vehicles. It is also used commercially by one truck manufacturer in the United States.

The second major type of final drive unit is a combination assembly containing both the transmission and differential. This design is used in front wheel drive cars such as the DKW, SAAB, Citroen and others where the close coupling of the engine with the driving wheels makes such a design attractive. It is also used in rear engined cars such as the Volkswagen, Renault, Porsche, and the small Fiat 600. Figure 6 depicts the Fiat 600 combined transmission and differential and is typical of this general design. One interesting feature of this type of design is that the flow of power is transferred from the input shaft to the output shaft and does not go through an intermediate step as in the conventional constant mesh transmission shown in Figure 5. While the Fiat 600 transmission is a four speed unit, it is synchronized in only the three top forward speeds. Since passenger space is not taken up by the drive line, as in a conventional drive system, the differential gears can be of the spiral bevel type. This results in lower frictional losses and lighter differential gear loads.

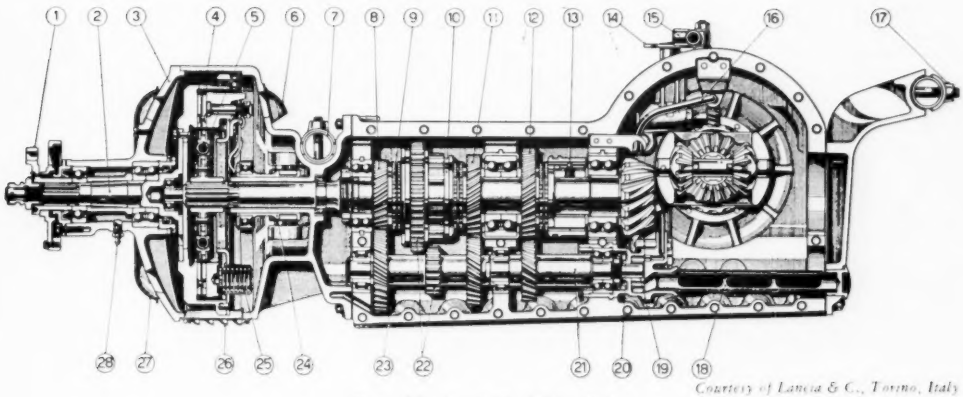
One of the most interesting of all of the combination transmission and differential units is that used by Lancia on their Aurelia and Flaminia. As shown in Figure 14, this unit contains the clutch, transmission, differential unit and rear brakes.

The clutch, which precedes the transmission, is of conventional design having a single dry plate and is hydraulically actuated by a clutch pedal at the driving position. The transmission is of four speed design with the top three speeds fitted with constant load synchronizers. The differential gears are of hypoid design with a moderate offset to lower the drive line. The rear brakes are also mounted as a part of this unit to reduce the unsprung rear axle weight. The drive is then transmitted to the rear wheels through short independent axles fitted with universal joints at each end. The rear axle, as shown in Figure 20, is of the deDion type and will be discussed later. This general design was originally developed for use in the very fast and successful Lancia racing machines. A similar unit is now used by Ferrari in their racing cars. One advantage of this arrangement is that it improves the weight distribution and allows greater acceleration since more of the weight is on the driving wheels. Obviously, it is not a design for use in moderate or low priced cars.

Lubrication of Final Drive Units

Gear lubricants suitable for use in differentials and transmissions must have special properties. Their major function is to prevent the scoring and welding of the meshing gear teeth which could result from the high gear loads employed by these designs. In order to do this, the gear oil must have certain Extreme Pressure (EP) properties which will protect the gear surfaces and prevent scoring. The gear oil must also have a sufficiently high viscosity so that it is not thinned excessively by high temperatures. It must have good low temperature properties and be resistant to oxidation.

Gear lubricants for use in the "hypoid" type of gearing and in some spiral bevel gear systems, do have Extreme Pressure properties and are referred to as EP Gear Oils. They are available in several viscosity grades as shown previously by the SAE Gear Oil Viscosity Classification in Table III.



Courtesy of Lancia & C., Torino, Italy

Figure 14 — Lancia Final Drive Unit

1—Propeller shaft coupling, 2—Clutch mainshaft, 3—Clutch housing, 4—Clutch disc, 5—Clutch disc hub, 6—Clutch housing vent, 7—Front transmission mount, 8—Idler shaft drive gear, 9—Fourth speed synchronizer, 10—Third and fourth speed synchronizer sleeve, 11—Third speed gear, 12—Second speed gear, 13—Second speed synchronizer sleeve, 14—Oil filler cap with dip stick, 15—Hydraulic brake connection, 16—Oil supply pipe, 17—Rear transmission mount, 18—Oil pump intake screen, 19—Oil pump, 20—Hypoid pinion gear, 21—Transmission idler shaft, 22—First speed gears, 23—Idler shaft gear, 24—Clutch release bearing sleeve, 25—Clutch pressure plate springs, 26—Clutch housing vent, 27—Clutch housing vent, 28—Clutch mainshaft grease fitting.

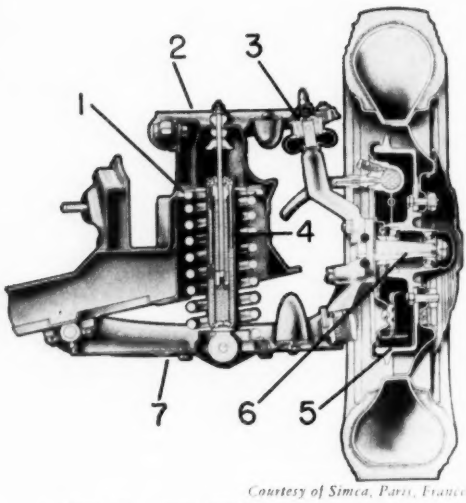
It is still the practice of some manufacturers to indicate that only certain brands of gear oils are satisfactory in their designs. In the case of gear oils available in the United States this is not necessary. Most service station lubricants meet the performance requirements of Military Specification MIL-L-2105. This specification defines the requirements of three viscosity grades of gear oil which must meet certain gear load, oxidation, and corrosion prevention tests. This system is not in use as yet in the European area, however, "multi-purpose" or "universal" gear oils made in the United States and marketed in the European area do meet these requirements.

Engine oils are not usually specified for use in differential units since they are not normally available in the desired viscosity grades and probably do not have adequate EP properties. Table IV lists the recommended viscosity grades and types of lubricants recommended for use in the differential and final drive units of those 1957 and 1958 European Cars on which information is available.

Lubrication of these units is generally provided by the splashing of the oil contained in the bottom of the differential gear case. This type of lubrication is also used in the combined transmission and differential units with the exception of the Lancia unit, which uses an oil pump to discharge oil at the point where the pinion and ring gear come into mesh.

SUSPENSION SYSTEMS

The requirements of a good suspension system are easily envisioned but are difficult to achieve. The basic purpose of all suspension systems is to provide the maximum of passenger comfort consistent with vehicle safety. To do this, the wheels must maintain constant contact with the ground under all conditions of road surface. This is the essential point, for it is the contact between the wheel and road that provides the steering, braking, and driving forces without which a car could not operate. Basically the wheel is maintained in contact with the road by the force of the car springs which transmit the weight of the car to the wheels. The amount of wheel bounce obtained as a result of a bump is directly proportional to the speed of the vehicle and inversely proportional to the stiffness of the spring. This wheel motion is modified by the use of a shock absorber which slows down the wheel action to control its motion and prevent excessive rebound. A further factor affecting wheel movement is the weight of the wheel, the tire, and the suspension assembly which is between the spring and the road. This weight is referred to as the "unsprung weight" since it is not supported by the springs as is the chassis. When this weight is large, the movement of the wheel in response to a bump tends to increase unless the spring is made stiffer. However, the use of stiffer springs tends to defeat one of the main purposes of a suspension, namely, to provide passenger comfort. The ideal suspension would have no weight at all, however, this is not possible since the tire and wheel weights do have an irreducible minimum. In an effort to achieve a light weight suspension, most all manufacturers use some sort of independent suspension for the front wheels and some also use it for the rear although satisfactory riding character-



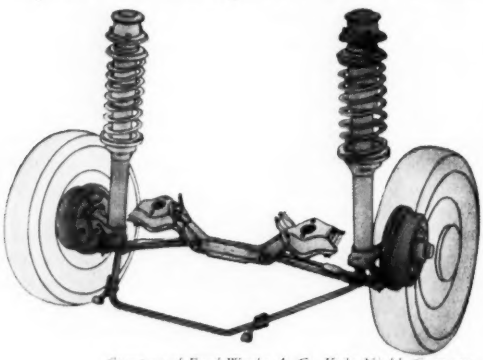
Courtesy of Simca, Paris, France

Figure 15 — Simca Aronde Front Suspension Unit
1—Coil spring, 2—Upper control arm, 3—Upper ball joint, 4—Shock absorber, 5—Front wheel brake drum, 6—Front wheel spindle, 7—Lower control arm.

istics can be obtained without going to this extreme. Other factors which also affect riding and handling qualities are the variables of wheel camber, caster, vehicle weight distribution, placement of roll centers, suspension geometry, tire inflation pressures, etc. These will not be discussed since they are beyond the scope of this article.

Front Suspension Systems

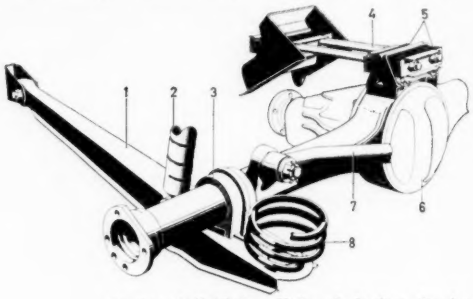
Almost all automobiles in production today use an independent front suspension system. A majority of the designs are based on the use of an upper and a lower control arm of "wishbone" configuration which support the wheel and are attached to the front springs and shock absorbers. A typical design of this type can be found in the Simca Aronde front suspension shown in Figure 15. Another interesting design which has been used to a limited extent allows the front wheels to move vertically on pillars which incorporate the front spring and shock absorber. This type of design is found in the Ford Taunus shown in Figure 16 and is also used in the Ford Zephyr and Zodiac. A modification of this arrangement is used on the Lancia in which the vertical tube is mounted to a solid front axle.



Courtesy of Ford Werke A. G., Koln-Niehl, Germany

Figure 16 — Ford Taunus 17M Front Suspension.

Another front suspension system that has received only limited use is the so-called "trailing arm" design. This arrangement provides for wheel



Courtesy of Aktiebolaget Volvo, Gothenburg, Sweden

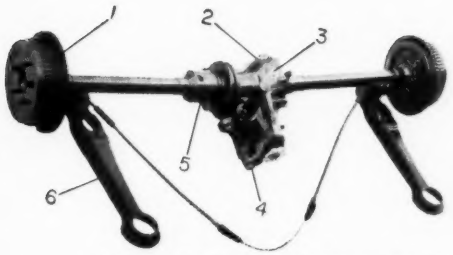
Figure 17 — Volvo PV-444 Rear Suspension.
1—Longitudinal stabilizer, 2—Shock Absorber, 3—Axle mounting with rubber isolator, 4—Axle torque reaction bar, 5—Axle torque reaction bar mounting with rubber isolator, 6—Differential housing, 7—Panhard rod, 8—Coil spring.

motion through the use of two parallel trailing arms which support the wheel and brake assembly. This arrangement is used by Volkswagen and Porsche. A somewhat similar system is used in the Citroen DS-19 wherein the parallel arms tend to push the wheel, or in other words, the wheel leads the control arms. This system is quite satisfactory since the Citroen uses a front wheel drive.

Front suspension springing utilizes many different designs. The most widely used spring is the coil as shown in Figure 15. Other arrangements use transverse leaf springs which form a structural part of the suspension. This design is used by A.C., Bristol, Fiat 500 and 600, and Peugeot. Others such as Volkswagen, Porsche, Riley, Morris, BMW and Allard use torsion bars as springs.

Rear Suspension Systems

Rear suspension systems are also of many different designs. The majority of the European Cars use a system where the rear axle and differential are one unit. The unit axle may be sprung by the use of either coil or leaf springs. This design is also widely used in the United States. In order to reduce the amount of unsprung weight and still retain the manufacturing economies inherent in the use of such an axle, some manufacturers use coil springs for the rear suspension. A typical design of this type is found in the Volvo PV-444 shown

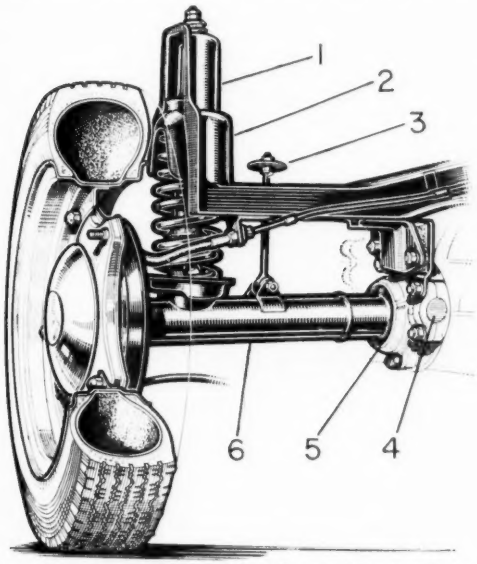


Courtesy of Daimler-Benz A. G., Stutgart, Germany

Figure 18 — Mercedes-Benz 190SL Rear Axle.
1—Brake drum, 2—Differential housing, 3—Differential support bracket, 4—Swing axle pivot point, 5—Universal joint and spline housing, 6—Longitudinal stabilizer.

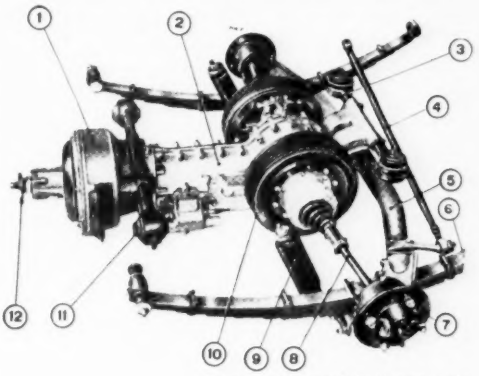
in Figure 17. Since the leaf spring is not used, other means for locating the axle relative to the chassis must be used. In this case, a longitudinal control arm restricts the front and back motion whereas a "Panhard Rod" restricts the sideways motion. Axle torque is absorbed by a special arrangement fitted to the top of the differential housing.

Independent rear suspensions are of two major types. One is the so-called "swing" axle and the other is the "deDion" design. Swing axles are one of the best practical approaches to the problem of reducing unsprung weight although they are more expensive than the unit axle. A typical "swing" axle can be found in the Mercedes-Benz 190 SL as shown in Figure 18. In this arrangement, the chassis is supported by coil springs. The axle is located by means of longitudinal control arms and is restricted as to sideways motion by the fact that the differential unit is attached to the chassis. A different type of "swing" axle is that used in the Renault Dauphine shown in Figure 19. Since the Renault is a rear engined car, the use of swing axles was dictated by the desire to obtain a compact mounting of the engine, transmission, and differential. Swing axles are also used by Porsche and Volkswagen, however, these two use torsion bar springs in place of the coil units employed by



Courtesy of S.A. des Usines Renault, Billancourt, France

Figure 19 — Renault Dauphine Rear Suspension.
1—Shock absorber mount, 2—Rear spring mount, 3—Rebound stop, 4—Axle pivot point, 5—Axle universal joint housing, 6—Axle tube.



Courtesy of Lancia & C., Torino, Italy

Figure 20 — Lancia Aurelia Rear Suspension.
1—Clutch housing, 2—Transmission case, 3—Rear transmission mount, 4—Panhard rod, 5—deDion axle, 6—Semi-eliptic leaf spring, 7—Left rear wheel hub, 8—Left rear wheel drive shaft, 9—Shock absorber, 10—Brake drum, 11—Front transmission mount, 12—Propeller shaft coupling.

Renault. Many racing cars use this design since it gives exceptional road holding ability due to its low unsprung weight.

The deDion type of assembly combines the features of both of the above designs. It is strong and yet allows a low unsprung weight. This arrangement is also widely employed in racing car designs and is used by Lancia as shown in Figure 20. In this instance, conventional leaf springs are used to transmit the driving and braking forces to the chassis. Allard also uses a deDion type of rear suspension but employs coil springs whereas the Frazer-Nash uses torsion bars in place of either leaf or coil springs.

The Citroen uses trailing arms for the rear suspension and a hydropneumatic suspension for both front and rear. In this system, hydraulic pressure developed by an engine driven pump is metered to hydraulic cylinders attached to the suspensions of each of the four wheels. The hydraulic assemblies also contain a chamber filled with inert gas which acts as the spring. The flow of hydraulic fluid as

TABLE IV – Transmission, Final Drive and Chassis Specifications and Lubricant Recommendations

			Transmission					Final Drive				Chassis		
						SAE Oil Viscosity Grade and Type				SAE Oil Viscosity Grade and Type		Suspension Type		
Make	Model	Clutch Type	Type	No. of Forward Speeds	Refill Capacity U.S. Qts.	Above	Below	Gear Type	Refill Capacity U.S. Pts.	Above	Below	Front	Rear	Brakes Type
AC (Note 1)	2 Liter, Ace, Aceca, Ace-Bristol, Aceca-Bristol	SDP	M-ODO	4	1.8 (2.7)[a]	40[b]	30[b]	Hy	3.6	90EP	90EP	ITR	IC	HDOF
Alfa Romeo (Note 1)	1300 Giulietta, Giulietta-Sprint Veloce, Spyder	SDP	M	4	1.7	90	90	Hy	3.0	90EP	90EP	IC	C	H
	1900 C, TI, Super	SDP	M	4	1.5	90	90	Hy	6.0	90EP	90EP	IC	C	H
Allard (Note 2)	Monte Carlo, Safari													
	Jaguar Engine	SDP	M	4	1.5	30	30	Hy	3.0	90EP	80EP	IT	CDD	H
	Cadillac Engine	TC	Auto	4	12	ATF	ATF	Hy	3.0	90EP	80EP	IT	CDD	H
	Palm Beach Mk II													
	Jaguar Engine	SDP	M-ODO[m]	4[m]	1.5 (2.4)[m]	30[m]	30[m]	Hy	4.2	90EP	80EP	IT	CDD	H
	Zodiac Engine	SDP	M-ODO	4	1.5 (2.4)	80EP	80EP	Hy	4.2	90EP	80EP	IT	CDD	H
	J3 Racing	SDP	M	4	1.5	30	30	Hy	3.0	90EP	80EP	IT	CDD	H
Alvis (Note 2)	3 Liter TD 21	SDP	M	4	1.8	30	30	Hy	2.6	90EP	90EP	IC	SE	H
Armstrong Siddeley (Note 3)	Sapphire 346	SDP	M	4	3.6	30	30	Hy	3.0	90EP	80EP	IC	SE	HSA
	Sapphire 346 (Special)	TC	Auto	4	12	ATF	ATF	Hy	3.0	90EP	80EP	IC	SE	HDSA
	Sapphire 234, 236	SDP	M-ODO[e]	4	2.1 (3.0)	30	20	Hy	3.0	90EP	80EP	IC	SE	HSA
Aston Martin (Note 2)	DB2-4 Mk II	SDP	M	4	1.5	90	90	Hy	2.4	90EP	90EP	IC	C	HDSA
	DB2-4 Mk III	SDP	M-ODO	4	1.5 (2.4)	90	90	Hy	2.4	90EP	90EP	IC	C	HDOFSA
Austin (Note 4)	A-30, A-35	SDP	M	4	1.4	30	30	Hy	2.3	90EP[d]	90EP[d]	IC	SE	H
	A-40, A-50, A-55, A-95, A-105	SDP	M-ODO	4	2.4 (3.0)[d]	30	30	Hy	2.4[d]	90EP[d]	90EP[d]	IC	SE	H
	A-95, A-105 (Auto. Trans.)	SDP	Auto	3	9.0	ATF	ATF	Hy	3.6	90EP[d]	90EP[d]	IC	SE	H
	Princess	TC	Auto	4	12	ATF	ATF	Hy	3.6	90EP	90EP	IC	SE	HSA
Austin-Healey (Note 1)	BN4 (100-Six), Sprite	SDP	M-ODO[e]	4	2.4 (3.0)[e]	30	30	Hy	3.6[f]	90EP	90EP	IC	SE	H
Bentley (Note 2)	S Series, Continental	TC	Auto	4	12	ATF	ATF	Hy	1.8	90EP	90EP	IC	SE	HMA
	(Conv. Trans.)	SDP	M	4	3.6	80EP	80EP	Hy	1.8	90EP	90EP	IC	SE	HMA
BMW (Note 1)	501 (6 cyl.), 501 V8	SDP	M	4	1.4[g]	90	90	Hy	4.2	90EP	90EP	IT	T	H
	502S, 503, 507	SDP	M	4	1.4	90EP	90EP	Hy	4.2	90EP	90EP	IT	T	H
	Isetta 300	SDP	M	4	0.6	40	40	Ch	0.3	40	40	IC	CL	H
	Isetta 600	SDP	M	4	1.3	30	20W	Sp		Comb. with Trans.		IC	CL	H
Borgward (Note 1)	Isabella, Isabella TS	SDP	M	4	1.1	90	90	Hy	3.2	90EP	90EP	IC	SWC	H
Bristol (Note 2)	403, 404, 405, 406	SDP	M-ODO	4	1.8 (2.7)	50	20	Hy	3.6	140EP	90EP	ITR	T	HDSA
Citroen (Note 1)	2CV (Type AZ)	SDP	M	4	1.1	80EP	80EP	Sp		Comb. with Trans.		IC	IC	H
	DS-19, ID-19	SDP	SA	4	2.7	90EP	90EP	Sp		Comb. with Trans.		IHP	IHP	HSADOF[h]
Daimler (Note 2)	Conquest, Century, Regency (One-O-Four), Mk II, Majestic, DK-400A	FC	SA[m]	4[m]	3.0[m]	30[m]	30[m]	Hy	3.6[i]	90EP	90EP	IC	SE	HSA
DKW (Auto Union) (Note 2)	3 = 6, 1000	SDP	M	4	2.4	90	90	Sp		Comb. with Trans.		ITR	SE	H

Facel Vega (Note 1)	HK-500, Excellence (Conv. Trans.)	SDP	M	4	2.4	90EP	90EP	Hy	3.9	90EP	90EP	IC	SE	HSAD
	Automatic Trans.	TC	Auto	3	12.7	ATF	ATF	Hy	3.9	90EP	90EP	IC	SE	HSAD
Ferrari (Note 1)	250 Gran Turismo	SDP	M	4	2.6	90EP	90EP	Sp	4.0	250	250	IC	SE	H
Fiat (Note 1)	La Nuova 500	SDP	M	4	1.2	90EP	90EP	Sp	Comb. with Trans.			ITR	SWC	H
	600, 600 Multipla	SDP	M	4	1.7	90EP	90EP	Sp	Comb. with Trans.			ITR[k]	SWC	H
	1100, 1100 TV, 1200 Full Light	SDP	M	4	1.2	90	90	Hy	1.2	90EP	90EP	IC	SE	H
	1400A, 1400B	SDP	M	4	1.5	90	90	Hy	2.4	90EP	90EP	IC	SE	H
	1900B Full Light	SDP	M-ODO	4	1.4 (2.3)[l]	90[l]	90[l]	Hy	2.6	90EP	90EP	IC	SE	HSA
Ford (Note 5)	Popular	SDP	M	3	0.6	90EP	80EP	Sp	1.2	90EP	80EP	TR	TR	M
	Anglia, Prefect	SDP	M	3	1.1	90EP	80EP	Sp	1.8	90EP	80EP	IC	SE	H
	Consul, Consul Mk II	SDP	M-ODO	3	1.5 (1.9)	80EP	80EP	Hy	3.0	90EP	80EP	IC	SE	H
	Zephyr Six, Zodiac	SDP	M-ODO[m]	3[m]	1.5 (1.9)[m]	80EP[m]	80EP[m]	Hy	3.0	90EP	90EP	IC	SE	H
Ford-Taunus (Note 2)	12M	SDP	M	3 or 4	1.1[n]	90EP	80EP	Hy	1.2	90EP	80EP	IC	SE	H
	15M, 17M	SDP	M	3 or 4	1.6[n]	90EP	80EP	Hy	2.3	90EP	80EP	IC	SE	H
Frazer-Nash (Note 1)	Continental, Sebring	SDP	M	4	1.2	90EP	90EP	Sp	2.0	90EP	90EP	IC	DDT	H
Goggomobil (Note 1)	T-250, T-300, T-400, TS-400	MWP	SA	4	1.6	ATF	ATF	Sg	Comb. with Trans.			IC	SWC	H
Goliath (Note 2)	GP-900E, 1100, 1100 DeLux	SDP	M	4	2.1	30	20	Sg	Comb. with Trans.			ITR	SE	H
Hillman (Note 6)	Minx Series III	SDP	M	4	1.5	30	20	Sp	2.1	140EP	90EP[o]	IC	SE	H
	Husky Series I	SDP	M	4	1.7	30	20	Sp	2.1	140EP	90EP[o]	IC	SE	H
Humber (Note 7)	Hawk	SDP	M-ODO[m]	4[m]	1.2 (2.4)[m]	30[m]	30[m]	Hy	2.1	90EP	80EP	IC	SE	H
	Super Snipe Mk IV	SDP	M-ODO[m]	3[m]	3.0 (4.2)[m]	30[m]	20[m]	Hy	4.8	90EP	80EP	IC	SE	HSA
Jaguar (Note 2)	2.4 Liter	SDP	M-ODO	4	1.5 (2.4)	30	30	Hy	3.0	90EP	90EP	IC	CL	HSA
	3.4, XK-150, Mk VII (Conv. Trans.)	SDP	M-ODO	4	1.5 (2.4)	30	30	Hy	4.2	90EP	90EP	IC	SE[p]	HSA[q]
	3.4, XK-150, Mk VII, VIII, IX (Auto. Trans.)	TC	Auto	3	9.0	ATF	ATF	Hy	4.2	90EP	90EP	IC	SE	HSA[q]
Jensen (Note 2)	541, 541R	SDP	M-ODO	4	3.9 (4.8)	30	30	Hy	3.6	90EP	90EP	IC	SE	HSAD
Lagonda (Note 2)	3 Liter	SDP	M	4	1.4	90	80	Hy	2.4	90EP	90EP	IC	DDC	HSAD
Lancia (Note 1)	Aurelia 2500 GT, Flaminia	SDP	M	4	3.5[r]	90EP	90EP	Hy	Comb. with Trans.			IC	DDSE	H
	Appia Series 2	SDP	M	4	1.4	90EP	90EP	Hy	3.2	140EP	90EP	IC	DDSE	H
Maserati (Note 1)	AG6 2000	SDP	M	4	2.3	90EP	90EP	Sp	2.8	90EP	90EP	IC	CDD	H
	Sport 2000	SDP	M	4	2.9	90EP	90EP	Sp	3.0	90EP	90EP	IC	CDD	H
Mercedes-Benz (Note 1)	180, 180a, 180D, 190, 190SL, 219	SDP	M	4	1.5	ATF	ATF	Hy	4.6[s]	90EP	90EP	IC	SWC	H[t]
	220S, 220SE	SDP	M	4	1.5	ATF	ATF	Hy	4.6	90EP	90EP	IC	SWC	HSA
	300D, 300S, 300SC	SDP	M[u]	4[u]	1.5[u]	ATF[u]	ATF[u]	Hy	4.6[v]	90EP	90EP	IC	SWC	HSA
	300SL	SDP	M	4	1.5	ATF	ATF	Hy	4.6[w]	90EP	90EP	IC	SWC	HSA
Messerschmitt (Note 1)	KR-200, KR-201	MDP	M	4	0.7	80	80	Ch	None Used			IR	IC	H
Metropolitan (Note 8)	1500	SDP	M	3	2.7	30	30	Hy	2.0	90EP	80EP	IC	SE	H

TABLE IV (Cont'd) – Transmission, Final Drive and Chassis Specifications and Lubricant Recommendations

Make	Model	Clutch Type	Transmission Type	Transmission No. of Forward Speeds	Transmission Refill Capacity U.S. Qts.	Transmission SAE Oil Viscosity Grade and Type Above	Transmission SAE Oil Viscosity Grade and Type Below	Final Drive Gear Type	Final Drive Refill Capacity U.S. Prs.	Final Drive SAE Oil Viscosity Grade and Type Above	Final Drive SAE Oil Viscosity Grade and Type Below	Chassis Suspension Type Front	Chassis Suspension Type Rear	Chassis Brakes Type
MG (Note 1)	MGA, Twin-Cam	SDP	M	4	2.4	30	30	Hy	3.3	90EP	80EP	IC	SE	H[x]
	Magnette	SDP	M	4	2.4	30	30	Hy	3.4	90EP	80EP	IC	SE	H
Morgan (Note 2)	Plus 4	SDP	M	4	1.5	30	30	Hy	3.0	90EP	90EP	IC	SE	H
	4/4 Series II	SDP	M	3	1.1	80EP	80EP	Hy	2.4	90EP	90EP	IC	SE	H
Morris (Note 2)	Isis (Series II)	SDP	M[m]	4[m]	2.7 (3.4)[m]	30[m]	30[m]	Hy	4.5	90EP	80EP	IT	SE	H
	Minor 1000	SDP	M	4	1.4	30	30	Hy	1.8	90EP	80EP	IT	SE	H
	Oxford (Series III), Cowley	SDP	M	4	2.7	30	30	Hy	3.3	90EP	80EP	IT	SE	H
NSU (Note 2)	Prinz II	SDP	M	4 Engine, Trans. and Diff. Comb. Cap. 2.3 qts.				Sg	–	–	–	IC	IC	H
Opel (Note 1)	Olympia, Rekord, Kapitan	SDP	M	3	1.1[y]	80	80	Hy	2.1	90EP	90EP	IC	SE	H
OSCA (Note 3)	1100 2-AD	SDP	M	4	1.1	40	40	Sp	1.4	140EP	90EP	IC	C	H
Panhard (Note 3)	Dyna	SDP	M	4	0.9	90EP	80EP	Sp		Comb. with Trans.		SWC	SE	H
Peugeot (Note 3)	203, 403	SDP	M	4	1.6	40	40	Wo	3.0	140[z]	90[z]	ITR	C	H
Porsche (Note 2)	356A/1300, 1300S, 1500GS, 1600, 1600S	SDP	M	4	3.7	90EP	80EP	Sp	–	Comb. with Trans.		IT	SWT	H
	550A/1500RS (Spyder)	SDP	M	4	–	Special Racing Oil		Sp	–	Comb. with Trans.		IT	SWT	H
Renault (Note 1)	750 4CV, Dauphine	SDP	M	3	1.0	80EP	80EP	Sp		Comb. with Trans.		IC	SWC	H
	Fregate	SDP	M[aa]	4	0.6[aa]	80EP	80EP	Hy	1.6	80EP	80EP	IC	C	H
Riley (Note 2)	1.5 Liter	SDP	M	4	3.0	30	30	Hy	2.1	90EP	80EP	IT	SE	H
	2.6 Liter	SDP	M[m]	4[m]	2.7[m]	30[m]	30[m]	Hy	4.5	90EP	80EP	IT	SE	HSA
Rolls Royce (Note 2)	Silver Wraith, Silver Cloud	TC	Auto[bb]	4[bb]	12[bb]	ATF[bb]	ATF[bb]	Hy	2.1	90EP	90EP	IC	SE	HMA
Rover (Note 2)	60, 75, 90E	SDP	M-ODO	4	2.1 (3.3)	20	20	Sp	3.6	90EP	80EP	IC	SE	H
	105S	SDP	M	4	3.3	20	20	Sp	3.6	90EP	80EP	IC	SE	HSA
	105R	SDP	M[m]	4[m]	2.4[m]	20[m]	20[m]	Sp	3.6	90EP	80EP	IT	SE	HSA
SAAB (Note 5)	93B, GT-750	SDP	M	4	2.2	90EP	80EP	Sp	–	Comb. with Trans.		SWC	IT	H
Simca (Note 1)	Aronde, Montlhery, Ariane 4	SDP	M	4	1.2[cc]	80EP	80EP	Hy	2.3[cc]	90EP	90EP	IC	SE	H
	Ariane V-8, Vedette	SDP	M	3	1.6	90EP	80EP	Hy	2.6[dd]	90EP	80EP	IC	SE	H
Singer (Note 2)	Gazelle (Series IIA)	SDP	M	4	1.7	30	20	Sp	2.1	90EP[dd]	80EP	IC	SE	H
Skoda (Note 1)	440, 445, 450	SDP	M	4	1.3	140EP	90EP	Hy	4.3	140EP	90EP	IT	IT	H
	1201	SDP	M	4	0.8	140EP	90EP	Hy	3.0	140EP	90EP	IT	IT	H
Standard (Note 2)	Eight, Ten, Pennant, Ensign	SDP	M-ODO	4	0.9[ff]	30[ff]	20	Hy	1.8	90EP	80EP	IC	SE	H
	Vanguard III	SDP	M-ODO	3	0.9[ff]	30[ff]	20	Hy	1.8	90EP	80EP	IC	SE	H
Sunbeam (Note 1)	Mark III	SDP	M	4	1.4	30	30	Sp	2.1	90EP	90EP	IC	SE	H
	Rapier (Series II)	SDP	M-ODO	4	1.4 (2.4)	30	30	Sp	2.1	90EP[ee]	90EP	IC	SE	H

Talbot (Note 1)	2500 Rapide, Talbot-America	SDP	M	4	1.6	90EP	90EP	Hy	2.7	90EP	90EP	IC	SE	H
Triumph (Note 2)	TR-3, Ten	SDP	M-ODO	4	0.9(1.8)	30[bb]	20	Hy	1.8	90EP	80EP	IC	SE	H
Vauxhall (Note 1)	Velox, Cresta, Victor	SDP	M	3	0.9	90	80	Hy	3.0	90EP	80EP	IC	SE	H
Volkswagen (Note 1)		SDP	M	4	2.2	90	80	Sp		Comb. with Trans.		IT	SWT	H
Volvo	PV-444L	SDP	M	4	0.6	80	80	Hy	2.0	80EP	80EP	IC	C	H
(Note 2)	Amazon	SDP	M	4	1.0	80	80	Hy	2.0	80EP	80EP	IC	C	H
Wolseley (Note 2)	Fifteen-Hundred	SDP	M	4	3.0	30	30	Hy	2.1	90EP	80EP	IT	SE	H
	Fifteen-Fifty	SDP	M	4	2.7	30	20	Hy	2.1	90EP	90EP	IC	SE	H
	Six Ninety	SDP	M-ODO[m]	4[m]	2.7(3.6)[m]	30[m]	20[m]	Hy	4.5	90EP	90EP	IT	SE	HSA

Abbreviations used above are as follows:
Lubricant viscosities shown as 20, 30, 40, 50 refer to SAE Motor Oil and 80, 90, 140 refer to SAE Gear Oil Viscosity Grades. EP indicates that a Multi-Purpose, Universal, or EP type of oil is recommended.

Clutch
SDP = Single Dry Plate
MDP = Multiple Dry Plate
MWP = Multiple Wet Plate
TC = Torque Converter
FC = Fluid Coupling

Transmission
M = Manual
Auto = Automatic
SA = Semi-Automatic
Pre = Preselective
ODO = Overdrive, Optional

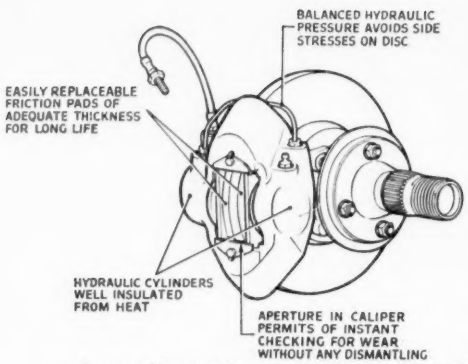
Final Drive
Hy = Hypoid Gearing
Sp = Spiral Bevel Gearing
Sg = Spur Gearing
Wo = Worm Drive
Ch = Chain Drive

Brakes
H = Hydraulic
D = Disc Brakes
DOF = Disc Brakes on Front
MA = Mechanically Assisted
SA = Servo Assisted (Power Brakes)

Suspension
I = Independent
SW = Swing Axle
DD = DeDion Axle
TA = Trailing Arm
TR = Transverse Leaf Springs
C = Coil Springs
SE = Semi-Eliptic Leaf Springs
CL = Cantilever Leaf Springs
T = Torsion Bar Springs
HP = Hydro Pneumatic Springs
R = Rubber Torsion (Springs)

(Note 1) Use indicated oil viscosity grades above and below 32°F in both Transmission and Final Drive Unit.
(Note 2) Use indicated oil viscosity grades above and below 10°F in both Transmission and Final Drive Unit.
(Note 3) Use indicated oil viscosity grades above and below 32°F in Transmission and above and below 10°F in Final Drive Unit.
(Note 4) Use indicated oil viscosity grades above and below 10°F in Transmission and above and below 32°F in Final Drive Unit.
(Note 5) Use indicated oil viscosity grades above and below 0°F in both Transmission and Final Drive Unit.
(Note 6) Use indicated oil viscosity grades above and below −10°F in Transmission and above and below 32°F in Final Drive Unit.
(Note 7) Use indicated oil viscosity grades above and below −10°F in both Transmission and Final Drive Unit.
(Note 8) Use indicated oil viscosity grades above and below 32°F in Transmission and above and below 0°F in Final Drive Unit.

References:
[a] Numbers in ( ) denote transmission capacity if fitted with overdrive.
[b] Ace Bristol, Aceca Bristol recommend use of SAE 50 above and below 32°F.
[c] Semi-Automatic available on Sapphire 236, same refill cap as manual transmission.
[d] 2.7 qts. in A-55 transmission if fitted with Manumatic, 3.6 pts. in A-95 and A-105 differential if fitted with Manumatic. Use 80EP below 10°F in all models.
[e] Optional overdrive not available on Sprite.
[f] 2.5 pts. in Sprite, use SAE 80 under 10°F.
[g] 1.6 qts. in 501 6 Cylinder Model.
[h] No servo assist in ID-19.
[i] 3.0 pts. in Conquest and Century.
[j] Disc brakes not available on Regency (One-O-Four).
[k] Independent suspension with coil springs used on 600 Multipla.
[l] If fitted with fluid coupling, use ATF, capacity 2.7 qts.
[m] If fitted with automatic transmission, use ATF, capacity 9.0 qts.
[n] Capacity 1.5 qts. if fitted with 4-speed transmission.
[o] Below −10°F use 80EP.
[p] 3.4 uses cantilevered leaf springs for rear suspension.
[q] Disc brakes available on all but 3.4. Std. on Mk. IX.
[r] Flaminia 1958 capacity is 4.3 qts.
[s] 180 below Chassis No. 12434 and 180D below Chassis No. 14468, capacity 3.4 pts.
[t] 190SL fitted with servo assisted brakes.
[u] 300D fitted with automatic transmission, capacity 9.5 qts. Automatic transmission optionally available on 219, 220s, 220SE.
[v] 300S and 300SC capacity 6.6 pts.
[w] 300SL before 1958 capacity 5.0 pts.
[x] Disc brakes fitted to Twin Cam.
[y] Kapitan Transmission capacity is 1.3 qts.
[z] Special product recommended.
[aa] If fitted with Transfluide semi-automatic transmission, capacity is 1.4 qts.
[bb] If fitted with manual transmission, SAE 30 recommended, capacity 3.6 qts.
[cc] Aronde Transmission capacity is 0.9 qts., differential capacity is 1.5 pts.
[dd] Vedette Marly capacity is 3.2 pts.
[ee] Above 32°F use 140EP.
[ff] Ten and Pennant 1.8 qts. with overdrive, Ensign and Vanguard III 1.7 qts. with overdrive.
[gg] In all but Ensign use SAE 40 above 90°F.
[hh] Above 90°F use SAE 50.


BALANCED HYDRAULIC PRESSURE AVOIDS SIDE STRESSES ON DISC
EASILY REPLACEABLE FRICTION PADS OF ADEQUATE THICKNESS FOR LONG LIFE
HYDRAULIC CYLINDERS WELL INSULATED FROM HEAT
APERTURE IN CALIPER PERMITS OF INSTANT CHECKING FOR WEAR WITHOUT ANY DISMANTLING

Courtesy of Standard Motor Co. Ltd., Coventry, England

Figure 21 — Schematic View of Disc Brake Assembly.

it transmits the wheel force to the inert gas is controlled so as to act as a shock absorber. Another interesting feature of this system is that the suspension height can be adjusted according to the wish of the driver to compensate for road conditions.

Lubrication of Suspension Systems

In spite of the many different suspension systems available, most include points which must be lubricated periodically. Generally, the manufacturer recommends that this be done at frequent intervals such as every 1000 to 2000 miles in order to insure that wear is kept to a minimum. Unfortunately, since the supply of lubricant at any particular joint is not subject to inspection as is the engine oil, little thought is given to chassis lubrication intervals. Should the supply be depleted so that severe wear were to occur, the average driver is usually not aware of this fact since differences in riding quality as a result of lack of lubrication are often not immediately noticed. For this reason, it is important that chassis lubrication be performed at frequent intervals if wear is to be minimized.

Chassis lubricants must provide a film of lubricant between slowly moving parts which are operating under extremely high pressures. This necessitates the use of a grease or a heavy lubricating oil. The lubricant must resist wash-out by water and must also protect the working parts from rust in case water does enter the chassis joint. Many manufacturers recommend specific brands although any reputable product should be satisfactory.

BRAKES

Finally, one of the most important parts of any vehicle are its brakes. Ideally, the brake must not "fade." Brake "fade" can best be described as that condition where repeated or prolonged brake applications have raised the temperature of the brake drum and lining to the point where mechanical dimensions and the frictional characteristics of the brake lining are temporarily altered. In this condition, the brake lining can no longer slow the car as well as when the brake was cold and thus increased pedal pressure is usually necessary. In addition to this loss of stopping power, brake fade also tends to increase brake pedal travel due to the high temperature having expanded the brake drum away from the brake shoe. Most manufacturers use hydraulic brakes of the internal expanding type. This arrangement utilizes two brake shoes which are forced out against the brake drum through the action of hydraulic pressure. However, due to the shrouding action of the wheel, cooling air is restricted in this design and, were not auxiliary cooling device supplied, brake fade would soon occur upon repeated brake applications. Some manufacturers such as Mercedes-Benz, have supplied cooling fins on the brake drum as is shown in Figure 18. To eliminate brake fade, an increasing number of cars are being equipped with disc brakes. As shown in Figure 21, a disc brake consists of a disc, attached to and rotating with the wheels, and a caliper arrangement fitted with two hydraulic pistons and two friction pads. The application of hydraulic pressure by the brake pedal, clamps the disc between the two friction pads and retards its motion. The brake pedal forces necessary to brake a car equipped with disc brakes are higher than one fitted with the drum type of design. This system is essentially "fade" free since brake surfaces can be easily cooled and high disc temperatures do not adversely affect the disc dimensions. The pedal forces required can be reduced by the use of a vacuum booster in the hydraulic system. Among the cars using this system as either optional or standard equipment on the front or on all four wheels are the Triumph TR-3, MGA, Lotus, Jaguar, Jensen, Citroen DS-19, Bristol, Aston Martin, Armstrong Siddeley and Ferrari.

Since the brakes must dissipate large amounts of energy as heat, the wheel bearings may also be subject to high temperatures. For this reason care should be used in the selection of the wheel bearing grease. The grease used should not fluidize or thin out as a result of high temperatures or the shearing action of the ball or roller bearings. If this does occur, the grease will leak, coat the braking surfaces, and promote erratic brake action.

SUMMARY

It is evident from the foregoing that European Cars offer a very wide variety of designs in all size categories. However, their lubrication requirements are not unusual and can be satisfactorily met by the oils and greases available in the United States. The acceptance of this fact by European manufacturers would do much to remove the European Car from the ranks of a "special" vehicle and would further promote their acceptance in the United States.

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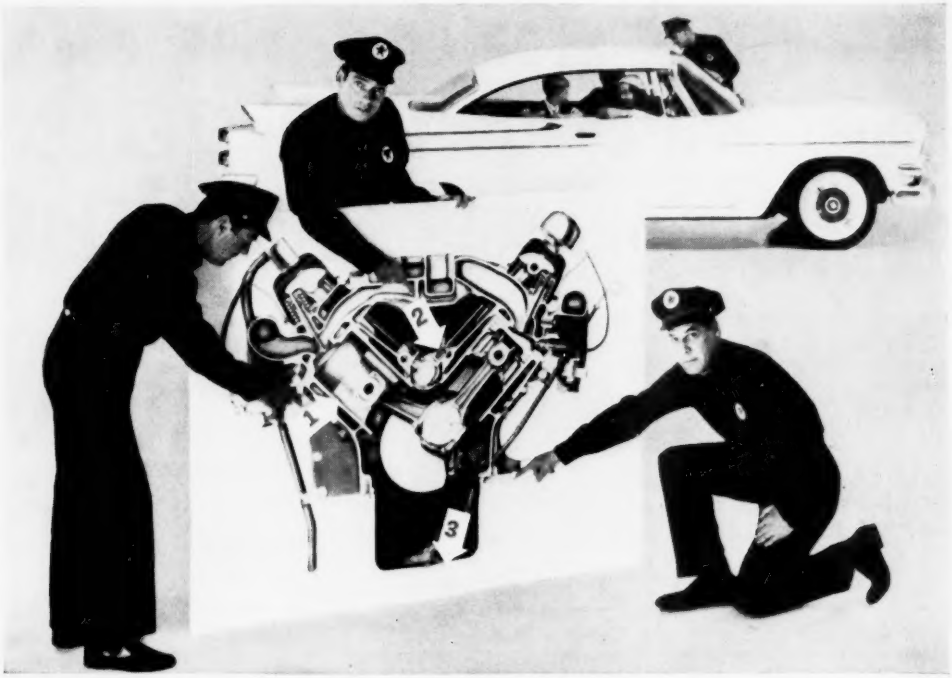

New All-Temperature Havoline gives maximum protection against wear

HERE'S WHY:

1. You get maximum protection against cold-start wear! Unlike ordinary motor oil, all-temperature Havoline Special 10W-30 stays free-flowing even in dead of winter. Coats surfaces with a rustproof, scuff-proof film the instant you flick the starter. You start faster. You get maximum protection against *hot-running wear!* All-temperature Havoline's tough body resists extremes of engine heat and pressure.

2. You get greater gasoline mileage, pep and power. There's always a protective film between moving parts, such as all-important cams and valve lifters.

3. You get maximum protection against sludge and deposits. *This oil cleans as it lubricates!* Prevents sludge and deposits so engine runs smoother, quieter, more reliably. Change your oil every 1,000 miles and make sure it's all-temperature Havoline Special 10W-30 . . . *the best motor oil your money can buy!*

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